ENVIRONMENTAL ASSESSMENT OF A PERMIT FOR THE INCIDENTAL TAKE OF SHORTNOSE STURGEON AT THE ROSETON AND DANSKAMMER POINT GENERATING STATIONS

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1. INTRODUCTION

This Environmental Assessment (EA) addresses the issuance of an Incidental Take Permit pursuant to Section 10 of the Endangered Species Act (ESA) for the incidental take of shortnose sturgeon (*Acipenser brevirostrum*) resulting from the operation of cooling water systems at two existing power plants, the Roseton and Danskammer Point power plants, located on the Hudson River estuary (Estuary). Issuance of an incidental take permit is a Federal action subject to consideration pursuant to the National Environmental Policy Act (NEPA) of 1969. The purpose of NEPA is to promote the analysis and public disclosure of environmental issues surrounding a proposed Federal action. The EA has been prepared to evaluate the potential significance of the issuance of the requested incidental take permits. As part of its permit application, Central Hudson Gas & Electric Corporation (CHGE) has prepared a Conservation Plan (ASA 2000) that includes minimization, monitoring, and adaptive management strategies to ensure that the continued operation of these two plants will not jeopardize the recovery of shortnose sturgeon in the Hudson River.

The Roseton and Danskammer Point power plants are located along the Estuary approximately 65 miles upriver (River Mile 65) from the southern tip of Manhattan (Figure 1-1). Danskammer Point is owned by CHGE, whereas Roseton is jointly owned by CHGE, Con Edison, and Niagara-Mohawk Power Corporation. Shortnose sturgeon, on rare occasion, have been collected in the cooling water withdrawal systems of these existing power plants. These incidental collections occur during the course of the intake operation permitted by the New York State Department of Environmental Conservation (NYSDEC) as part of the State Pollution Discharge Elimination System (SPDES). In addition, shortnose sturgeon have been occasionally collected in biological monitoring programs which have been required by the NYSDEC as part of SPDES permits for operation of these plants or by other agreements. The collection of shortnose sturgeon under this biological monitoring program is considered in this assessment and is addressed through an application for a Scientific Research Permit to cover these activities. This EA also considers the potential cumulative impacts on shortnose sturgeon resulting from other power plant cooling water withdrawals on the Hudson River estuary.

1.1 REGULATORY BACKGROUND

The ESA provides for a process to list fish, wildlife, and plant species as threatened or endangered and provides for the protection and conservation of those listed species and their habitat. The responsibility of administering the ESA is delegated to the U.S. Fish and Wildlife Service (USFWS) for terrestrial and freshwater species and to the National Marine Fisheries Service (NMFS) for most marine and anadromous species. One of the protections afforded to endangered species under the ESA is the prohibition against "taking" of any listed species. In Section 9 of the ESA, "take" is defined as "to harass, harm, pursue, hunt, shoot, wound, trap, capture, or collect" or any attempt to do so.

Recognizing that it was impracticable to prohibit the “taking” of all endangered or threatened individuals, Congress, in 1982, added Section 10 to the ESA which allows for the “incidental take” of these protected species by non-federal activities. Incidental take is defined by the ESA as take that is “incidental to and not the purpose of, the carrying out of an otherwise lawful activity.” To provide for the regulation and control of these incidental takes, an “incidental take permit” process was established under Section 10(a)(1)(B) of the ESA. This section allows both USFWS and NMFS to authorize the incidental take of endangered or threatened species provided that the health and potential recovery of these protected species is not jeopardized. To provide this assurance of protection, Section 10(a)(1)(B) calls for the preparation of Conservation Plans for the potentially affected species. These Plans are to be developed cooperatively between the permit requestor and the USFWS and/or NMFS and are to include detailed site-specific conditions, including mitigation and monitoring, which will ensure the conservation, and aid in the recovery, of the affected species.

1.2 ORGANIZATION OF DOCUMENT

Following this introduction, Chapter 2 describes the proposed action and the power plants associated with this action. Chapter 3 describes all alternatives considered under this proposed action. Chapter 4 describes the affected environment and presents a summary of key life history characteristics, distribution, and status of the shortnose sturgeon in the Estuary. Finally, Chapter 5 assesses the environmental consequences of the proposed activity, including the cumulative impacts of all known takes of shortnose sturgeon in the Estuary. Chapter 6 includes a Finding of No Significant Impacts (FONSI) and Chapter 7 lists those agencies and individuals consulted as part of the preparation of this document.

2. PROPOSED ACTION

The proposed action considered under this EA is the issuance of a permit for incidental take of shortnose sturgeon through cooling water withdrawals at the Roseton and Danskammer Point power plants that are currently operated by CHGE.

2.1 PURPOSE AND NEED

Incidental Take Permits, issued under Section 10 of the ESA, authorize the incidental take of endangered species, such as shortnose sturgeon, when such takes will not jeopardize the continued recovery of the endangered species of concern. The operation of the subject power plants to produce electrical power entails the withdrawal of water from the Estuary. This activity may result in collection of shortnose sturgeon. Take can be authorized under the ESA under section 10 for non-federal actions and section 7 for actions that are conducted, authorized, or funded by a federal agency. Initially discussions were held between NMFS and EPA to determine if a section 7 consultation could be conducted on the issuance of a discharge permit from EPA to the facilities. EPA's position was that there was no federal action as they had previously delegated the discharge permit to the state. NMFS then approached NYSDEC to determine if they would apply for a permit to cover a range of power projects on the river. When that option was not pursued, the utilities contacted the NMFS to initiate the process to obtain permits under section 10 of the ESA.

Roseton and Danskammer Point are important components of CHGE's overall system for providing electrical power to consumers in New York State. In fact, these two plants represent 90 percent of CHGE's total generating capacity and their continued operation is critical to overall system reliability. Owing to limited generating and transmission capacity, CHGE could find itself unable to provide power to all of its customers during periods of peak demand and specific transmission line operating scenarios should either plant not be in operation.

The production and high voltage transmission of electricity in New York is currently regulated by the New York Independent System Operator (ISO). The ISO is required to commit generating units so as to reliably serve the New York electrical load at the lowest total cost. Agreements adopted with the ISO require CHGE to own or have contracts for generating capacity sufficient to meet projected summer peak loads plus an additional 18 percent to account for unanticipated events. If either plant were unable to operate, it is unlikely that CHG&E could meet these requirements, especially during periods of peak demand when replacement power would be unavailable. Thus, the continued operation of Roseton and Danskammer Point is critical to the overall plan for a reliable power supply for New York State as a whole.

2.2 POWER PLANT DESCRIPTIONS

While the focus of this EA is on two power plants, Roseton and Danskammer, information on four other power plants located in the middle reaches of the Hudson River estuary is also presented for purposes of assessing cumulative impacts.

2.2.1 Cooling Water System Operation

Water from the Estuary is supplied to the condenser cooling water and the service water systems of the power plants. Service water systems cool plant components (e.g., bearings) that require heat removal for proper functioning, provide water for washing the intake traveling screens, and may also be used for supplemental fire protection purposes.

Each of the power plants employs a once-through condenser cooling water system in which water is directly withdrawn from the Estuary, used for cooling purposes, and then returned directly to the Estuary at a slightly elevated temperature. While the design of each cooling system varies from plant to plant, all have similar basic components and functions. Water is withdrawn from the Estuary through an intake structure that may be located at the shoreline or set back from the shoreline in an intake canal. Typically, the cooling water first passes through trash racks that are fixed, fence-like structures with slot-openings typically 2–3 inches wide. These trash racks prevent large debris, such as logs and large ice floes, from entering the intake and damaging the finer mesh traveling screens. The cooling water then flows into the intake forebay and through vertically rotating traveling screens (Figure 2-1). These traveling screens prevent smaller material such as leaves, aquatic vegetation, and fish from entering the plant’s cooling water system. The traveling screens are rotated vertically and all collected materials are washed from the screen into a sluiceway. This material (including both debris and fish) then rapidly flows back to the Estuary along with the screen wash water. These screen washings are returned to the Estuary well away approximately 200 to 1,000 ft. from the intake.

After passing through the traveling screens, the water is pushed by circulating water pumps through the plant’s cooling water system. Cooling water then passes through the condenser tubes where it is used to condense steam for plant operations. This passage through the condensers results in the heating of the water, typically in the range of 5^{o} to 20^{o}C above ambient water temperatures. This heated water then enters a discharge pipe or canal and is returned to the Estuary away from the plant's intake in order to minimize the potential for recirculation of heated discharge water. Some of these power plants use a series of submerged portholes or diffusers at the point of discharge to allow for rapid and efficient mixing of the heated water with the receiving water. The operation of the cooling water systems at each power plant is regulated under SPDES permits or other agreements. The sections below provide specific information on the cooling water facilities at each power plant. Each section includes a brief description of the location, design, and operation of the plant and its anticipated operation.

2.2.2 Roseton Generating Station

The Roseton Generating Station is located on the west shore of the Estuary at RM 66 and approximately 4 mi north of the Newburgh-Beacon Bridge (Figure 1-1). The plant consists of two fossil-fueled, steam electric units, having a combined net generating capacity rating of 1,248 MWe. This plant is jointly owned by CHGE, Con Edison, and Niagara-Mohawk Power Corporation; however, all operations are directed by CHGE. Roseton Unit 1 began commercial operation in December 1974 and Unit 2 in September 1974.

The Estuary in the vicinity of Roseton is about 4,000 ft wide and 50 ft deep on average. The plant is located in the northern portion of an area known as Newburgh Bay that is up to 1 mi wide just south of Roseton. Roseton is within the salt-intruded reach of the Estuary only when the freshwater flow is low for extended time periods; salinity in the vicinity rarely exceeds 2 ppt (approximately 1/15 seawater).

Roseton has a shoreline intake structure that is shared by both units (Figure 2-2). There are 12 openings or portals on the front face of the intake structure with bar or trash racks located between the portals and the traveling screens. Of the eight traveling screens installed at the plant, six are conventional vertical-rotating, single-entry, band-type screens flush mounted to face the waterway and two are dual-flow (double entry/single exit), band-type screens mounted perpendicular to the waterway. When only one unit is operating, one or two circulating water pumps are typically used. When two units are operating, two, three, or four pumps are used depending on ambient temperature. When both units are in operation, normally three circulating water pumps will be operated for a combined flow of 561,000 gpm. From the condensers, the combined cooling water is discharged into the Estuary perpendicular to the direction of river flow through a submerged, multi-port, high-velocity diffuser at a distance of approximately 120 ft offshore.

In 1997, CHGE installed a low-capacity booster pump at the Roseton intake to provide service water flow and fire protection to both generating units. This booster pump, which has a designed capacity of approximately 12,000 to 14,000 gpm depending on tidal levels, permits Roseton to shut down all circulating water pumps when both generating units are off line.

2.2.3 Danskammer Point Generating Station

The Danskammer Point Generating Station is located on the west shore of the Hudson River estuary at RM 66, adjacent to and approximately 0.5 mi north of the Roseton Generating Station (Figure 1-1). Estuary conditions in the vicinity of Danskammer Point are expected to be identical to that described for Roseton. Danskammer Point began operation in 1951 and presently consists of four fossil-fueled, steam electric units, having a net generating capacity rating per unit ranging from 480 to 491 MWe.

Each of the four units at the Danskammer Point Station has a separate once-through cooling water system. Cooling water is transported to the plant through an intake canal located along the estuary shoreline north of the plant. This 450 ft long and 34 ft wide canal, which is protected by a debris boom and trash rack at the estuary end, leads to a common intake bay from which water is diverted into the individual cooling systems through a series of conventional vertical traveling screens (Figure 2-3).

Units 1 and 2 each are equipped with two circulating water pumps. Each pump has a designed pumping rate of 21,000 gpm. Unit 3 has two circulating water pumps, each with a designed pumping rate of 41,000 gpm. Unit 4 has three circulating water pumps, each with a designed pumping rate of 50,000 gpm. During the winter, one circulating water pump at each of Units 1, 2, and 3 and two circulating pumps at Unit 4 are operated for a combined flow of 183,000 gpm. For normal operations during the summer, an additional pump per unit is also operated resulting in a maximum combined flow of 316,000 gpm. From the condensers, cooling water is discharged to the Estuary through three separate shoreline subsurface pipes on the south side of the plant.

2.2.4 Other Power Plant Operation

In addition to the two power plants that are the focus of this EA, four other power plants are located along the Mid-Hudson River estuary and utilize water from the estuary for cooling purposes. A brief description of these plants is presented below. Details on plant operations and cooling water intake design and operation are presented in the Conservation Plan.

Bowline Point

The Bowline Point Generating Station is located on the west bank of the Hudson River estuary at RM 38 (Figure 1-1). The plant consists of two fossil-fueled, steam electric units, each having a net generating capacity rating of 600 MWe for a total net generating capacity of 1,200 MWe. Owned and operated by Southern Energy New York, Unit 1 began commercial operation in September 1972 and Unit 2 in May 1974. Total maximum cooling water withdrawals at this plant are approximately 514,000 gpm when both units are in operation.

Lovett

The Lovett Generating Station is located on the west bank of the Hudson River estuary at RM 42, just north of Stony Point, New York (Figure 1-1). This plant consists of three fossil-fueled, steam electric units, having net generating capacities ranging from 63 to 202 MWe for a total of 463 MWe for all units combined. Lovett operates as a baseline plant on a demand basis with Units 3, 4, and 5 fully operational. Units 1 and 2 were retired in January 1996. Owned and operated by Southern Energy New York, Unit 3 began commercial operation in March 1955, Unit 4 in May 1966, and Unit 5 in April 1969. Total maximum cooling water withdrawals for Units 3–5 are approximately 273,000 gpm when all three units are in operation.

Indian Point

The Indian Point Generating Station is located on the east shore of the Hudson River estuary at RM 43, almost directly across the Estuary from Lovett (Figure 1-1). The station consists of three pressurized-water nuclear reactors. Unit 1, owned by Con Edison, began commercial operation in August 1962 and was retired in 1974. Unit 2 (rated at 1,008 MWe), owned and operated by

Con Edison, and Unit 3 (rated at 1,034 MWe), owned and operated by New York Power Authority (NYPA), have produced electricity since June 1973 and August 1976, respectively. Owing to different ownership, these two Units are considered separate power plants. Total maximum cooling water withdrawals for both operating units at this generating station range from approximately 1,000,000 gpm during winter to approximately 1,700,000 gpm during the warmer months of the year.

3. ACTION ALTERNATIVES

As required under Section 102(2)(E) of NEPA and the National Oceanic and Atmospheric Administration (NOAA)'s Procedures for Implementing NEPA (NOAA 1999), a variety of reasonable alternatives for the proposed action must be considered under an EA. This consideration must include the alternative preferred by those proposing the action as well as a "no action" alternative that will serve as a baseline for comparison. Each of the alternatives considered in this EA are discussed below. Also included is a description of other alternatives that were considered and rejected as being either infeasible or providing little, if any, incremental benefit to the shortnose sturgeon.

3.1 PREFERRED ALTERNATIVE 1 — IMPLEMENTATION OF CONSERVATION PLAN

This alternative entails operation of the Roseton and Danskammer Point power plants in accordance with CHGE's Conservation Plan (ASA 2000). The overall biological goal of this Plan is to minimize, to the maximum extent practicable, the collection of shortnose sturgeon by the cooling water intake systems at the Roseton and Danskammer Point power plants and to ensure the continued recovery of the shortnose sturgeon population in the Hudson River estuary. This Plan includes specific mitigation and monitoring requirements for both plants. The mitigation activities also provide benefits to other species of fish in addition to shortnose sturgeon (CHGE *et al.* 1999). In addition, the Conservation Plan also includes an adaptive management strategy to address potential changed circumstances that can be identified. Each of these key Plan components is described below.

3.1.1 Mitigation Measures

Mitigation of impacts of the proposed action under Section 10 permitting usually takes one or more of the following forms:

- Avoiding the impact
- Minimizing the impact
- Rectifying the impact
- Reducing or eliminating the impact over time
- Compensating for the impact

To meet the mitigation requirements, the Conservation Plan includes programs that will minimize the potential entrainment and impingement of shortnose sturgeon at the Roseton and Danskammer Point power plants to the extent practicable. Such minimization measures are designed to insure that the operation of these two power plants will not appreciably reduce the likelihood of the survival and recovery of shortnose sturgeon in the wild and are not likely to likely jeopardize the continued existence, nor hinder the recovery, of shortnose sturgeon in the Estuary.

Historically, CHGE implemented measures to protect fish species in the Estuary, including requirements incorporated in existing SPDES permits issued by the NYSDEC. The SPDES permits currently include provisions to minimize impacts of entrainment and impingement on Hudson River fish populations, including shortnose sturgeon. These provisions include cooling water flow reduction programs to reduce the number of organisms entrained and continuous rotation of traveling screens to improve survival of organisms impinged on the intake screens.

CHGE will continue these programs in accordance with the requirements set forth in the current SPDES permits for the Roseton and Danskammer Point power plants. In addition, to recognize the possibility that in future SPDES permits NYSDEC may no longer require cooling water flow restrictions, monitoring, or mitigation consistent with current obligations, CHGE has stated that it will consult with NMFS to determine whether such future SPDES requirements are still adequately protective for shortnose sturgeon compared with the corresponding practices of the existing SPDES permits. In the interim, CHGE will continue existing mitigation measures.

The Roseton and Danskammer Point minimization programs presented in the Conservation Plan consist of the following:

(1) CHGE will assure thirty "unit-days of outage" at Roseton between 15 May and 30 June of each year that may be satisfied, at the discretion of CHGE, through any combination of outages, cross plant credits made available, or cooling water flow reductions as described in Appendix B. In addition, CHGE will use best reasonable efforts to keep the volumes of cooling water drawn into the Roseton power plant at the minimum required for the efficient operation of the plant. Such volumes and average maximum river water temperature are approximated below:

Time Period	Average Maximum River Water Temperature	Volume of Cooling Water Withdrawal
1 Jan–14 May	60ºF	418,000 gpm
15 May–14 Jun	71ºF	561,000 gpm
15 Jun–24 Sep	82ºF	641,000 gpm
25 Sep–16 Oct	72ºF	561,000 gpm
17 Oct–31 Dec	64ºF	418,000 gpm

When one unit at Roseton is out of service during the above time periods, the approximated flow rates shall be 70 percent of those set forth above for the respective period. Because the flow rate for any given period is dependent upon ambient river water temperature, flow rates for precise periods cannot be specified. Also, the flow rates may differ from those set forth in the chart because of the need to meet water quality standards or other conditions of the SPDES permits.

Danskammer Point will generally be operated with reduced cooling water flows of 220,000 gpm from 17 October through 14 May of each year. Throughout the rest of the year, cooling water flows will be reduced when electrical loads permit.

(2) In addition, off-peak cycling of circulating water pumps will be used when feasible at Roseton and Danskammer Point. The objective of this program is to reduce the volume of cooling water withdrawal during off-peak periods (evenings and/or weekends) when electrical loads are low, or when the units are not dispatched in the NY-ISO energy market, therein reducing the number of organisms entrained through the power plants. This supplemental flow reduction program is designed to reduce cooling water flow beyond what is typically required for efficient plant operations. The operating mode of circulating water pumps will be adjusted to (1) ensure compliance with SPDES permit thermal effluent limitations, and (2) utilize threshold generating unit output criteria for off-peak cycling of circulating water pumps.

(3) Roseton and Danskammer Point intake screens and fish return systems will be operated in continuous mode when circulating water pumps, which they serve, are operational in order to minimize injury and mortality of fish returned to the Estuary.

3.1.2 Monitoring

Section 10(a)(2)(A) of the ESA requires that a Conservation Plan submitted as part of an application for an incidental take permit include a monitoring program to assess the impact of the action to the protected species. More specifically, the Habitat Conservation Plan Handbook (USFWS and NMFS 1996) indicates that this monitoring should address three objectives:

- Periodic accounting of the take
- Species status in the project area
- Establish progress on fulfillment of mitigative requirements

In addition, specific targets or milestones should be established, to the extent practicable, which will extend throughout the life of the Conservation Plan. These targets or milestones can be used as trigger points for adaptive management options. The specific monitoring program developed by CHGE to meet these objectives is described below.

First, the CHGE Conservation Plan provides for an annual count of the number of shortnose sturgeon impinged at each facility based on sampling during one 24-hour period each week of operation. Sampling protocols will include provisions for rapid sorting of each collection to ensure any shortnose sturgeon are quickly recovered and returned to the Estuary with as little additional stress as possible. The actual count of shortnose sturgeon collected as well as the length, weight, condition, and disposition of each individual collected will be presented for each facility in a quarterly report that will be submitted to NMFS within 1 month following completion of the quarter.

CHGE will conduct this monitoring as long as such monitoring is a requirement of the SPDES permit. The actual count of shortnose sturgeon collected as well as the length, weight, condition, and disposition of each individual collected will be presented for each facility in a quarterly report that will be submitted to NMFS within 1 month following completion of the quarter. Based on the expectation that the studies discussed in the Conservation Plan will also be part of the SPDES permit issued by NYSDEC for each facility, any related correspondence will be provided to both NMFS and NYSDEC. Should the SPDES permit for either facility no longer require routine impingement monitoring, CHGE will, prior to ceasing such monitoring, request a meeting with NMFS to discuss the need for future monitoring at either Roseton or Danskammer Point. Monitoring changes will not be implemented until agreed to by the NMFS.

Second, CHGE will conduct a mark-recapture study designed to estimate the population size of adult shortnose sturgeon in the Estuary twice during the 15-year term of the permit (permit years 7 and 14). The results of this study are expected to provide useful information on the long-term trends in the population of adult shortnose sturgeon in the Estuary. The level of effort and general study methodology will be similar to the recently completed study by Cornell University (Bain *et al.* 1998). CHGE may, in its discretion, combine this population study with any other studies, if appropriate, to maximize efficiencies towards achieving desired monitoring goals. CHGE will provide support funding up to a maximum of $200,000 for all such studies. CHGE provide NMFS with a study plan at least 3 months prior to initiating the study and provide study results, along with the data collected, no later than 3 months after completion of the study..

3.1.3 Changed Circumstances/Adaptive Management

Section 10(a)(2)(A) of the ESA and subsequent implementing agreements requires that a Conservation Plan submitted as part of an application for an incidental take permit must include procedures to deal with changed circumstances through adaptive management strategies. "Changed circumstances" is defined as circumstances affecting a species or geographic area covered by the Conservation Plan that can be reasonably anticipated by plan developers and the USFWS or NMFS and planned for. An adaptive management strategy provides for changes in the minimization, mitigation, and/or monitoring requirements of the Conservation Plan to address the changed circumstances.

Three types of potential changed circumstances are addressed in the Conservation Plan as well as CHGE's adaptive management approach, as described below.

(1) <u>Listing or delisting of species potentially affected by the operation of the Roseton or Danskammer Point cooling water system.</u> Should additional species be added to the list of protected species under the ESA, CHGE will then apply for an amendment to the Conservation Plan to address the newly listed species. Should all species addressed in the Conservation Plan become delisted for the Hudson River estuary, this permit would no longer be valid or necessary. Continued monitoring and/or mitigation would be covered under the SPDES permitting process managed by the NYSDEC.

(2) Biologically significant increases in the take of shortnose sturgeon at the Roseton or Danskammer Point Generating Stations. Should the 5-year rolling average of the estimated annual take of shortnose sturgeon exceed authorized take levels under the Permit at either Roseton or Danskammer Point, CHGE will meet with NMFS to discuss the increase in take and to determine whether or not it poses a risk to the shortnose sturgeon population. Should there be indications that these increases may jeopardize the health, condition, or potential recovery of the shortnose sturgeon in the Estuary, CHGE and NMFS will then work jointly to determine what additional mitigative measures can be reasonably achieved to protect this species. Even if the increases are not at a level to pose jeopardy, CHGE will discuss and may voluntarily adopt appropriate mitigative measures.

(3) Biologically significant decrease in the population of shortnose sturgeon in the Hudson River estuary. Should the shortnose sturgeon population substantially decrease in the Hudson River estuary, then CHGE will meet with NMFS to discuss whether or not currently permitted takes are greater than can be sustained by the population. If there is clear indication that such permitted takes are greater than can be sustained by the existing population, then CHGE and NMFS will work jointly to determine what additional mitigative measures can be reasonably achieved to protect this species.

3.2 ALTERNATIVE 2 — ADDITION OF CLOSED-CYCLED COOLING

The existing cooling water systems are once-through, open-cycle cooling water systems, as described previously in Chapter 2. Alternatively, heat from the condenser cooling water may be transferred to the atmosphere using closed-cycle cooling systems, such as cooling ponds, spray ponds, or various cooling tower technologies. In this alternative, the existing once-through systems would be replaced with closed-cycle systems and the amount of cooling water withdrawn from the Estuary would be reduced to less than 10 percent of the once-through levels.

One commonly used method of closed-cycle cooling involves the use of cooling towers. Cooling towers may be wet or dry, or a combination ("wet-dry") of the two, and use natural circulation or mechanically impelled airflow to cool the water. With wet cooling towers, the majority of the heat transfer from the water to the atmosphere occurs through evaporation. In dry towers, which have no direct contact between the air and water, cooling occurs entirely through convection. Wet towers may circulate air using natural drafts created by the warmed air or by mechanical fans. Dry towers use only mechanical draft. In a few special situations, systems have been built with both wet and dry cooling elements. The wet components provide the majority of the cooling, while the dry components can be used in conjunction on occasions when atmospheric conditions warrant. While the total number of organism entrained under closed-cycle operation is likely to be comparable to the reduction in total cooling water flow ($\geq$ 90 percent), all organisms entrained will perish from the cooling tower process. On the other hand, significant entrainment survival would be expected for relatively hardy species like shortnose sturgeon under once-through operation. Thus, reductions in the number of organisms lost attributable to installation of cooling towers is likely to be considerably less than the reduction in the number of organisms entrained.

Use of evaporative cooling has potentially significant impacts for the Hudson River valley from formation of fogging or icing from the cooling tower plume drift. Therefore, the alternative of wet-dry towers is the cooling tower alternative considered as most appropriate for the two power plants considered herein. Wet-dry towers combine evaporative and convective cooling to allow the higher efficiency of evaporative cooling, while reducing some of its environmental impacts. The formation of plumes and the associated icing and fogging events can be reduced, but usually not eliminated. Visual impacts due to the structures, evaporation, drift, blowdown, sludge formation, and noise would remain essentially like those of the associated wet tower component.

Since the plume produced by wet towers occurs when the moisture content of the air above the cooling tower exceeds the saturation level for the air temperature, two mechanisms may be invoked to reduce the frequency of plume formation. The amount of moisture transferred to the air can be reduced, and the temperature of the air can be increased. Incorporating a dry heat transfer section into a mechanical cooling tower can accomplish both. A dry section in a wet tower, by providing a stream of relatively warm dry air to be mixed with the air from the wet sections, can reduce the tendency for droplet formation. However, these sections are space consuming, costly, and can impose significant efficiency penalties when applied to existing facilities.

Installation of cooling towers would have substantial detrimental environmental effects in other areas. These are detailed below:

1. Even with the selection of wet/dry mechanical towers, the aesthetic impacts would be substantial. At Roseton, 50 to 60-ft-high structures, hundreds of feet in length would be placed along or near the shore, much of which is currently open space. On some occasions plumes of vapor would extend hundreds of feet into the air and be visible from many miles away from the stations. Significant view sheds around each of the power plants in the Hudson Valley that would be affected.

2. Sufficient utility-owned land does not exist for the installation of cooling towers at Danskammer Point. For installation of cooling towers, adjacent properties would have to be acquired through condemnation, a process that is time consuming and costly.

3. Both power plants would experience substantial reductions in efficiency and de-ratings due to increased turbine backpressure and auxiliary power loads. This would reduce the output of the plants without reducing fuel consumption, emissions or other related impacts at Roseton and Danskammer Point. Replacement of the generation lost from Roseton alone due to the retrofitting would cost approximately $3,000,000 annually. At least part of this lost generation would be made up at other power plants with the consequent impacts occurring there. If new sources were required, the

impacts could include land and habitat disturbance, visual impacts, and the other effects of construction of a medium-sized power plant.

4. Most of the cooling provided by the cooling towers is produced by evaporation of water. The resulting drift, consisting of small airborne droplets of cooling water, would be continuously emitted into the ambient air. These droplets contain salts and chemicals present in the cooling tower water. Pollutants in the Hudson River intake water would be carried through and concentrated in the cooling tower and a portion of them would be dispersed into the ambient air with the drift. The drift would eventually reach the ground and contribute to ground level pollution. The drift rate in modern, well designed and maintained, cooling towers is on the order of 0.001 to 0.002 percent of the total flow rate. These rates would lead to deposits of salts that may be harmful to hemlocks in the region. Although wet/dry cooling towers were selected to minimize fogging and icing, some icing and fogging would occur downwind of the cooling towers during certain atmospheric conditions.

5. Cooling towers generate noise from their fans, as well as from the water that splashes through the tower. To reduce the noise emitted by the tower, low-speed, quiet fans would be used and the towers would be equipped with inlet air baffles and splash shields. The claimed effect of these provisions would be that the noise level at 400 ft from the towers would be expected not to exceed 50 dBA. More typically, noise levels of 65 dBA could be achieved with the low speed fans and high quality fan drives.

6. Blowdown discharge contains concentrated levels of salts and chemicals present in the makeup water, as well as chemicals added to prevent fouling.

7. Sludge would develop in the basin from silt and heavier suspended solids in the makeup. The sludge would have to be properly managed and the cost of testing, removal, and proper disposal could be substantial.

8. In order to install cooling towers at Danskammer Point, large tracts of land would have to be cleared of vegetation and large quantities of rock would have to be excavated and most of it would have to be disposed of. The site clearing, excavation, transportation of surplus material, and its disposal would impact the area with significant increases in noise, vehicular traffic, dust, and the potential spillage of earth and rock on the roads.

The total present value (1999) of retrofitting wet/dry-cooling towers at Roseton is $112 million not including costs for annual operation ($700-800 thousand) or replacement power ($3 million annually). Costs could be substantially higher if the tie-in periods are longer than those used for estimating purposes. Construction of similar cooling towers at Danskammer Point appears impractical due to the lack of sufficient property.

Although costly and presenting other environmental impacts, cooling towers were considered as a possible alternative for the operation of Roseton and Danskammer Point to reduce the take of shortnose sturgeon. Under an assumption of 80 percent entrainment survival for shortnose sturgeon under once through cooling, a 90 percent reduction in cooling water flow through installation of cooling towers would result in a 50 percent reduction in the lethal take of shortnose sturgeon.

3.3 ALTERNATIVE 3 — NO ACTION

Under this alternative, the NMFS would not issue a Section 10(a)(1)(B) permit for the incidental take of shortnose sturgeon by the operation of the two power plants and, consequently, implementation of species protection and minimization measures under the HCP would not be assured. Consideration of this alternative is specifically required by the Habitat Conservation Plan Handbook (USFWS and NMFS 1996).

3.4 OTHER ALTERNATIVES CONSIDERED

Several categories of alternatives have been evaluated for the Plan. Alternative means of utilizing the existing once-through cooling water systems are discussed under the heading of "3.4.1 Alternative Cooling Water Flows." Potentially applicable alternative technologies that entail replacement of the existing once-through cooling water systems with closed-cycle technologies are discussed under the heading of "3.4.2 Cooling Ponds/Spray Ponds." Alternative screening technologies are discussed under the heading of "3.4.3 Screening Alternatives," followed by a discussion of "3.4.4 Behavioral Barriers." In addition, the potential applicability of "District Heating and Cooling" is discussed in Section 3.4.5 and the potential for "Importation of Power" is discussed in Section 3.4.6.

3.4.1 Alternative Cooling Water Flows

In concept, it might be possible to "target" reductions in water withdrawal rates in an effort to reduce the entrainment or impingement of shortnose sturgeon, if the occurrence of entrainment or impingement events could be predicted. Even after adjusting the occurrences of impingement at the two power plants to account for periods not sampled, the actual impingement of a shortnose sturgeon is a relatively rare event that occurs without evident daily or seasonal pattern. The discussion of cumulative impacts on shortnose sturgeon suggest that the few, rare impingement events that do occur are not negatively impacting the recovery of the species. The occurrence of entrainment events is of even lower frequency. In addition, each of the power plants has, in the past, minimized its water withdrawals to those necessary for efficient operation of the plant and these practices are expected to continue in the future. Further water withdrawal restrictions would not produce discernible benefits to the species and would have adverse economic impacts to the power plants. Accordingly, this alternative was eliminated from further consideration in this EA.

3.4.2 Cooling Ponds/Spray Ponds

Cooling ponds must have a surface area large enough for sufficient heat exchange by evaporation and contact between water and air. The relatively smooth surface of ponds creates an inefficient contact between the air and water, so large surface areas are required. For generating stations the size of those on the Estuary, hundreds to thousands of acres of ponds would be required. Sufficient lands are not available for consideration of this technology.

Spray heads are among the most effective techniques to enhance the efficiencies of cooling ponds. Water is drawn from the ponds, ejected into the air through spray heads, and allowed to splash back into the ponds. The droplets formed by the spray heads have large surface-to-volume ratios so evaporative cooling takes place efficiently as they travel through the air. The splashing back onto the pond surface further increases the amount of liquid surface in contact with the air. These efficiencies come with the increased costs of equipment and energy for pumping. Spray ponds for power plants the size of those on the Hudson River estuary would have to range from 35 to 100 acres which exceeds the land available for such purposes at the plant sites. Consequently, this alternative was eliminated from further consideration in this EA.

3.4.3 Screening Alternatives

3.4.3.1 Fine-Mesh Screens

This alternative entails installation of screens with finer mesh than those presently deployed at the cooling water intake of each power plant. Conventional traveling screens, such as those used at Roseton and Danskammer Point, are constructed of wire mesh with 3/8 inch (9.5 mm) openings. The 2 dual-flow screens installed at Roseton are constructed of wire mesh with ¼ x ½ inch (6.4 x 12.7 mm) openings. Fine mesh screens considered under this alternative are typically constructed of wire mesh with 1/8 inch (3 mm) or smaller openings. These fine mesh screens can prevent fish eggs and larvae from entering a plant's cooling water system. However, the organisms excluded from entrainment end up being impinged upon the intake screens. Consequently, evaluation of this alternative involves a careful balancing of existing entrainment survival with potential impingement survival of normally entrained egg and larval stages.

The results of post-entrainment and post-impingement survival testing and evaluation of the influence of screen mesh size have been variable. Laboratory studies have found that post-impingement survival of larval and early juvenile fish is species specific, with some species exhibiting high mortality while other species experience relatively high survival regardless of screen mesh size or velocity (Edwards *et al.* 1981; Taft *et al.* 1981; McLaren and Tuttle 1999).

Survival is likely to be high for those impinged on conventional mesh screens, due to the belief that shortnose sturgeon are relatively hardy and resistant to physical stresses similar to those encountered in power plant impingement (Bain 1999, personal communication; O'Herron 1999, personal communication; Kynard 1999, personal communication). Thus, there appear to be no benefits to any shortnose sturgeon impinged. Further, as few shortnose sturgeon larvae are entrained and those that are likely experience high survival, it also appears that the potential benefits of this intake technology for shortnose sturgeon entrainment are also minimal.

In addition, significant engineering uncertainties associated with this technology would need to be overcome. For example, fine-mesh screens generate higher head losses for a given flow compared to screens equipped with larger sized mesh. This results from the lower percentage of open area of the mesh, which in turn creates higher through-screen flow velocities. The increased hydraulic losses associated with fine-mesh screening material places greater demands on the screen support structural components, mechanical components, and spray wash systems compared to conventional size mesh. Existing screen technology cannot meet these demands with acceptable reliability (Envirex 1993). Thus, more detailed engineering studies would be required prior to development of a full-scale screen system design that would be capable of operating reliably when outfitted with fine-mesh.

In addition, installation of fine-mesh screens would significantly increase debris loading, with plant operational and biological implications. Fish larvae post-impingement survival on fine-mesh screens is directly related to debris (quantity and type), with lower survival during high debris periods (Fletcher 1990). From an operational standpoint, the increased debris loading associated with fine-mesh screens could reduce plant efficiency and reliability by requiring stepped-up screen cleaning and maintenance and by degrading condenser performance if screens had to be taken out of service and the associated pumps shut down.

Until further studies have been completed, cost estimates cannot be reliably developed for this alternative. However, installation would require substantial intake modifications and thus is likely to be quite expensive. Based on engineering difficulties, potential high cost, and the lack of any identifiable environmental benefit with respect to shortnose sturgeon, this alternative was excluded from further consideration.

3.4.3.2 Barrier Nets

Barrier nets represent a physical exclusion system that prevents aquatic organisms from being exposed to either entrainment or impingement. Barrier nets have been determined to be effective at several locations, with successful deployment dependent on site conditions and facility operating conditions. For example, a seasonally deployed barrier net (9.5-mm mesh) has been shown to provide substantial and efficient impingement control at Bowline Point (Hutchison and Matousek 1988; NAI 1997). In addition, a fine-mesh barrier net (“Gunderboom”) is being tested at Lovett. Preliminary results show this system has some promise to reduce the entrainment of fish eggs and larvae if it can be successfully deployed. While a larger mesh barrier net offers the potential for reducing impingement of shortnose sturgeon, there is little if any additional benefit of going to a fine-mesh net to reduce entrainment as entrainment of shortnose sturgeon larvae appears to be minimal. Thus, this evaluation focuses on potential installation of a barrier net, similar to that found at Bowline Point, Roseton and Danskammer Point. As this technology can provide environmental benefits when successfully deployed, the evaluation of this alternative focuses on site-specific engineering considerations for deployment.

Factors to be considered in determining whether a barrier net can be successfully deployed at a site include water velocity (plant-induced and tidal currents), debris-loading potential (clogging and biofouling), bottom type, and water depth. A barrier net is best deployed in low velocity areas where a complete seal can be maintained. Theoretically, low approach velocities lower the risks of fish being impinged in the net and rapid clogging of the net by entrained debris (Michaud 1991). Thus, data on environmental conditions (storms, and wave or tidal variability) are necessary to properly design and determine the best deployment technique. Debris loading and biofouling must remain at a minimum to maintain the net's filtering capacity and site-specific conditions, such as bottom sediment type, impact on recreational or commercial boat traffic, and potential storm damage, should be considered.

At both power plants, barrier nets would be required to withstand tidal currents of 60–65 cm/sec. Seasonal debris loading would be the most significant deterrent to the use of a barrier net at either of these power plants. During the spring following ice-out, large quantities of debris, especially leaf litter and marsh grasses, are present in the Estuary. These materials could clog a barrier net; if exposed to strong tidal currents, a barrier net could be torn free from its anchor points. It is currently considered impractical to install a barrier net at Roseton or Danskammer Point due to the proximal positioning of water intakes to strong tidal currents, the water depth (30–40 ft near shore), the proximity of the main river channels, the seasonally high debris and sediment loading, and presence of structures located offshore of the intake at some of the facilities. It is for this reason that barrier nets were eliminated from further consideration as being impractical at either Roseton or Danskammer Point.

3.4.3.3 Cylindrical Wedge-Wire Screens

Cylindrical wedge-wire screens are essentially arrays of large diameter pipes with small perforations through which water can be withdrawn. The size (number, length and arrangement of the pipes) of the array depends upon the volume of water required and the desired velocity of the water entering the perforations. These screens have some potential to reduce entrainment, as well as impingement, at water intakes (SAIC 1994).

Cylindrical wedge-wire screening systems are generally designed to provide sufficient surface area to accommodate the required flow volumes at through-slot velocities of 0.5 fps (15 cm/sec) or less. The velocity of water approaching the slots declines rapidly with increasing distance from the screen and becomes negligible at several inches from the surface (SAIC 1994). These low approach velocities apparently are largely responsible for enabling even some weakly swimming organisms to avoid entrainment and impingement. Other parameters, which apparently influence the effectiveness of these systems, are the size of the slots, the orientation of the cylinders relative to the direction of the ambient currents, and the relative velocities of the through-slot and ambient currents.

Clogging of the perforations and a consequent loss of flow is a concern with these systems. Installation of fine-mesh cylindrical screens is limited at offshore marine locations because of the propensity for clogging by marine growth and debris and the difficulty of providing an effective cleaning mechanism at such locations. Where screens can be located close to shore, air backwash systems may be used to remove debris. In these systems, a large volume of air under high pressure (100 psi) is discharged periodically into the interior of each screen. The bursts of air remove debris accumulated on the outer surface. However, the airbursts may not effectively remove biological growth, debris accumulation on the inner surface, or fine materials wrapped around the screen mesh. Mechanical or even hand cleaning may be required. The frequency of cleaning must be evaluated site-specifically before an appropriate system can be designed. Under some conditions frazil ice must also be considered a potential source of flow interruptions. Frazil ice may form very rapidly during cold, clear, windy nights in water bodies with no ice cover. Wedge wire screens with small slot dimensions are particularly vulnerable.

To date, the application of cylindrical wedge-wire screens at power plants is primarily limited to relatively low flows such as for makeup water for a closed-cycle cooling system. Installation of large-scale systems, as would be required at Roseton and Danskammer Point, would face significant potential difficulties including permitting, reliability and maintenance issues, and cost. At the same time, environmental benefits over that of the existing intake design and operation remain uncertain for shortnose sturgeon. It is for these reasons that this intake alternative was excluded from further consideration with regard to shortnose sturgeon protection.

3.4.4 Behavioral Barriers

Behavioral devices produce a controlled stimulus that attracts or repels aquatic organisms. Behavioral system controlled stimuli include: visual stimulus (underwater strobe light, mercury vapor lights); acoustic or sound stimulus (pneumatic device, acoustic transducer); physical stimulus (electricity); and/or combinations (acoustic-electric fence). Typically, these behavioral systems include use of electrical barriers, air bubble curtains, hanging chains, underwater strobe lights, mercury lights, incandescent lights, water jet curtains, and sound (LMS 1988, 1992; SWEC 1986, 1994).

Since behavioral systems are relatively inexpensive compared to physical exclusion systems/structures and offer a low maintenance technique to mitigate plant operational impacts, a great deal of effort has gone into their evaluation. Behavioral systems including electric barriers, pneumatic guns, air bubble curtains, water jets, and chemical barriers have not proven effective at consistently modifying fish behavior to result in installation at intake structures. In addition, the behavioral systems that do result in positive behavior modifications have been found to be limited with respect to the species influenced or in some aspect of application, such as time of day. Of the behavioral systems evaluated, only lights and underwater sound have positively demonstrated acceptable levels of behavior.

At hydroelectric facilities, lights have been shown to be effective at minimizing turbine entrainment by directing the fish to a nearby bypass structure. However, special studies conducted at cooling water intakes on Lake Ontario and on the Estuary at Roseton revealed no significant exclusion potential from underwater strobe lights for any species of fish tested at either location. Thus, it appears that their use to reduce entrainment or impingement losses at conventional cooling water intakes is unproven.

Mechanically produced low-frequency sound has been evaluated as a technique to reduce impingement of fish at a variety of power plants, including Roseton on the Estuary. No consistent deterrent capability was determined for the mechanical devices. The low effectiveness determined for the devices coupled with mechanical reliability problems, especially in the turbid Estuary, did not indicate that this type of device would be an effective deterrent at limiting impingement at cooling water intake structures.

While electronically produced low frequency sound elicited a strong avoidance response in some species of fish during at least part of the day, tests at actual cooling water intakes have not resulted in acceptable effectiveness levels to indicate installation. High frequency sound produced by electronic systems has been tested on a variety of fish species. Results of these tests indicate that the sound system was effective at keeping two species of herring, alewife and blueback herring, away from an intake structure in Lake Ontario, with an effective exclusion range exceeding 80 m. The sound system resulted in significant reductions in impingement at that station.

Based on these results, it appears that high-frequency sound generated by acoustic deterrent systems is effective at limiting impingement of some herring species (alewife, blueback herring); however, neither low- nor high-frequency sound systems have been shown to be effective at limiting impingement of any other fish species. No data presently exist to determine the effectiveness of such systems for shortnose sturgeon. This alternative was eliminated from further consideration for shortnose sturgeon as part of this EA.

3.4.5 District Heating And Cooling

This alternative entails use of steam from generating stations as a source of steam for heating and/or cooling systems in the areas surrounding the stations. If sufficient heat could be extracted due to this process, then, presumably, less cooling water would be needed, resulting in reduced volumetric requirements for cooling water. However, due to the fact that the steam for district heating and cooling would have to be taken from a point in the Rankine cycle where the energy content of the steam is still relatively high, the extraction point would be prior to the point where the steam enters the turbine. Thus, shunting the steam to a district heating system would not capture waste heat that would otherwise have been transferred to the Estuary, but instead would use heat energy that otherwise would have been used to generate electricity. Unless the steam sent to the district heating/cooling system replaces energy that would have been supplied through electricity, this alternative would not reduce the need for generation from these facilities and even the very modest reductions in the amount of heat they put into the estuary would not be realized. Additionally, the cost of implementing district heating and cooling would be very high, especially given the insignificant reduction in waste heat that could be achieved. For these reasons, this alternative was excluded from further consideration in this EA.

3.4.6 Importation Of Power

Importation of power is a component of the proposed action and of the alternatives considered because service area power needs must be accommodated in all cases. Regional power shortfalls caused by outages and flow reductions at either Roseton or Danskammer Point must be compensated for by power production elsewhere. Any increases in the importation of power could have significant consequences in system reliability and cost for the electric consumer.

A corollary to importation of power is export of environmental impacts. The identity and extent of those impacts cannot be defined without knowledge of the source of the imported power and the focus of environmental impact. As the source of imported power is variable, so are the location and extent of impacts associated with it; however, to the extent that imported power would be generated at power plants with once-through cooling, there could be incremental impingement, entrainment, and thermal plume impacts at those facilities. The impacts that accrue to the locations where replacement power is produced cannot be identified or evaluated.

Given that the annual take of shortnose sturgeon that might be reduced through importation of power is very small and substantial uncertainties exist associated with system reliability and costs to the ratepayer, this alternative was excluded from further consideration.

4. AFFECTED ENVIRONMENT

4.1 GENERAL OVERVIEW

The Estuary consists of all of the tidally influenced Hudson River, extending from the southern tip of Manhattan north about 154 miles to the dam at Troy, including a modest amount of adjacent wetlands and the tidal portions of a number of small tributaries. The Estuary contains a wide variety of habitats. It is an open-ended system that interacts with both the coastal marine habitat and the freshwater habitat in tributary streams and ponded waters lying above the tide line. The physical and water quality attributes that result from the interplay of ocean tides and freshwater runoff influence the abundance and distribution of organisms residing in the Estuary biological community. This section summarizes these physicochemical attributes and the community composition and energy structures of the Estuary. It provides the ecological context for understanding the potential for power plant and monitoring program effects on the shortnose sturgeon population.

4.1.1 Geography/Physiography

The 315-mile-long Hudson River originates at Lake Tear-of-the-Clouds on the southwest slope of Mt. Marcy in the Adirondack Mountains. From its source the river flows approximately 160 miles in a south-southeast direction to its confluence with the Mohawk River. Two miles further downriver is the Federal Dam at Troy (River Mile 154), which creates a physical barrier between the upper and lower Hudson River. The Federal Dam prevents any tidal influence or fluctuations in the upper basin and marks the upper limit of the Estuary.

The Hudson River estuary, which is the focus of this EA, commences below the junction of the Mohawk and upper Hudson Rivers at Troy above Green Island and flows south to its discharge into New York Bay. This entire section of the river is tidal. Not including the upper Hudson and Mohawk River basins, the lower Hudson basin drains an area of approximately 5,277 square miles and is essentially a flooded valley with very little gradient. Over its 152-mile course below the dam to its mouth, the Estuary drops approximately 5 ft, or an average of 0.4 in. per mile.

The physiographic features of the Hudson River Valley were shaped by the geologic forces of the last ice age. As a result, the entire watershed is covered with a layer of glacial drift. As the glacier receded and the developing Great Lakes opened up, various outlets for the lakes were formed; the Mohawk-Hudson Valley was the eastern outlet (Flint 1957; Clayton 1967). Glaciation deepened the channel of the Estuary through the Hudson Highlands. The channel above and below the Highlands was not excavated as deeply, but was still partially filled with drift materials as the glacier receded. The clay and other fine sediments in the glacial drift covering the region still contribute much suspended material to its streams.

The Hudson River watershed comprises a diverse set of topographic features that influence the Estuary. Within the basin, 48 percent of the terrain is mountainous, 2 percent is lakes and water bodies, and about 50 percent is rolling hills and lower-elevation river valley. Covering a very small part of the watershed (<1 percent) are the low, but rugged, Highlands across the lower Hudson River. Elevations range from 1,200 to 1,400 ft. Although relief is commonly from 500–800 ft, where the Hudson River cuts through the Highlands at sea level, relief can reach >1,000 ft.

4.1.2 Human Use

Human settlement of the Hudson-Mohawk River basin began approximately 11,000 years ago, shortly after the retreat of the Wisconsin stage ice sheet. During the Woodland Stage, 60,000-70,000 people from at least five major Indian groups occupied the area (Salwen 1976). European colonization of the valley followed swiftly after Henry Hudson's initial explorations in 1609. By 1626, Dutch colonists were sending furs and samples of grain back to the Netherlands. The Hudson Valley was successfully settled because of its suitability for crops and agricultural practices familiar to the Dutch colonists (Meinig 1966). From 1664 until the time of the American Revolution, the area was controlled largely by the British. By 1775, the entire Hudson Valley from New York City to Glens Falls and the Mohawk Valley west to Amsterdam were considered settled (Meinig 1966).

The development of steam-powered travel, canal waterways, and railways in the early 1800s permitted increased settlement in the Mohawk Valley. The Erie and Champlain canal systems and the Mohawk and Hudson railroad were the initial transportation penetrations beyond Albany. As settlement of the upper reaches of the watershed increased, industrialization also increased. By 1910, there were approximately 1 million inhabitants in the 10 counties along the lower Hudson from Albany south, not including New York City. From 1910 to 1940, the population in the lower Hudson River basin expanded rapidly, to 8.9 million (including New York City). Most of the increase occurred in New York City and the counties of Rockland and Westchester. In the 1940s, growth was relatively uniform along the river, ranging from 6 to 10 percent for the decade. After 1950, the New York City population remained nearly constant, while the mid-Hudson and lower counties began a period of rapid growth that continues today.

Prior to the 1900s, the dominant industries were those of the primary sector (i.e., agriculture, forestry, fishing, and mining). These gave way during the early part of the century to a progressive increase in the secondary sector (i.e., manufacturing industries such as food products, textiles, apparel, pulp and paper, chemicals, leather, stone, metal, machinery, and transportation equipment). This stage peaked in the 1950s and 1960s. Since 1985, manufacturing has declined in seven of the nine counties in the lower Hudson Valley (Mid-Hudson Patterns for Progress 1992). In contrast, service industries, such as transportation, communication, public utilities, wholesale and retail trades, finance, insurance and real estate, repair, and others, have increased in all nine counties.

The Hudson River is used as a source of potable water, for waste disposal, transportation, and for cooling by industry and municipalities. Six municipalities currently use the lower Hudson River as a source of potable water. Rohman *et al.* (1987) identified 183 separate industrial and municipal discharges to the Hudson and Mohawk Rivers. The greatest number of users were in the chemical industry, followed by the oil industry, paper and textile manufacturers, sand, gravel, and rock processors, power plants, and cement companies. Approximately 20 publicly owned treatment works (POTW) discharge sewage and wastewater into the Hudson River. Most of the municipal wastes receive primary and secondary treatment. A relatively small amount of sewage is attributed to discharges from pleasure boats.

4.2 SUMMARY OF PHYSICAL CHARACTERISTICS

4.2.1 Basin Morphometry

The lower Hudson River estuary is 152 miles long from the Battery to Troy Dam. For ease of discussion the Estuary can be divided into five broad segments with similar morphometry (CHGE *et al.* 1999). The first segment extends from RM 152 to RM 94 and includes the regions of Albany, Catskill, and Saugerties. This 59-mile reach of river is narrow and has extensive shoals and 29 tributaries. The slope of the river bottom is also greatest in this section of the lower Estuary, which means that current velocities are generally greater in this segment than in other segments.

The second segment extends from RM 93 to RM 56 and includes the regions of Kingston, Hyde Park, Poughkeepsie, and Cornwall. This reach contains a series of progressively deeper (going downriver) basins. Although this reach is about two-thirds the length of the uppermost segment, its volume is more than 1.5 times that of the uppermost segment. This is the result of the constriction formed by the Catskill Mountains to the west and the Taconic Mountains to the east that caused the glaciers to cut more deeply into the floor of the Hudson River Valley as they passed through the segment. Shallow shoreline and shoal areas are common only in the southernmost end of the reach.

The third segment of the Estuary extends from RM 55 to RM 39 and includes several prominent points where the river bends sharply. The Hudson Highlands forced the glaciers through a narrow and tortuous path in this reach and they cut deeply into the valley floor. This is the deepest and most turbulent section of the river, greatly feared by the captains of sailing ships during colonial times. The river narrows abruptly, bends sharply, and increases dramatically in depth to over 150 ft. At the lower end of this segment, between RM 45 and RM 38, a series of progressively shallower gouges in the bedrock gives the river bottom a slanted corrugated form (much like that of an old-fashioned scrub board) as it rises to the shallows below the Hudson Highlands.

The fourth segment is short, extending from RM 38 to RM 24, and very broad, 2.5 miles wide. This is the widest and shallowest section of the Estuary and includes two prominent natural landmarks, Croton Point and Piermont Point. It has the most extensive shoal and shore zone areas. This is a major deposition zone within the river and the sediments have a relatively high organic content. Biologically, it is a productive area of the river, particularly as a nursery for juveniles of a variety of fish species.

In the fifth and final segment, extending from RM 23 to the Battery (RM 0), the Palisades again restricted the flow of the glaciers and the river narrows and deepens until it spills out into New York Harbor. The section is relatively straight, with few shoal areas or shore zone habitats. In the lower 12 miles there is relatively little natural shoreline remaining.

4.2.2 Freshwater Flow

Under normal summer conditions about 75 percent of the freshwater flow enters the lower Hudson River at Troy. Flow at this location is gauged at the USGS station at Green Island. Freshwater flows reaching this point are regulated by a series of dams, locks, and water supply reservoirs in the upper Hudson and Mohawk sub basins. Over 70 percent of the remaining freshwater flow enters via tributaries near the upper end of the Estuary. The major tributaries below the Federal Dam at Troy are Kinderhook Creek (RM 125), Catskill Creek (RM 113), Roeliff-Jansen Kill (RM 111), Esopus Creek (RM 103), Rondout Creek and Wallkill River (RM 92), Wappinger Creek (RM 67), and Croton River (RM 34). The remaining tributaries are generally smaller in size.

Based on data from 1947 through 1997, the average annual freshwater input at Green Island is 13,527 cfs. Average annual flow values are quite variable, ranging from a low of 7,750 cfs in 1965 to a high of 21,311 cfs in 1976. There was a period of severe drought during the 1960s and a period of extreme high flows during the 1970s .

On a seasonal basis, maximum freshwater flows occur primarily during March, April, and May, and low freshwater flows begin in June and continue until November. Spring freshets, tropical storms, and intense rainfalls can bring about sudden increases in flow. During these events, peak daily flows can be quite high. The maximum daily flow recorded at Green Island was 141,000 cfs on 31 December 1948. By way of contrast, the lowest recorded daily flow was 0 cfs on 28–30 April 1968. The high-flow events more likely to occur during the spring and fall result in less predictable flow conditions in these seasons than in winter and summer (Wells and Young 1992).

4.2.3 Tides

The lower Hudson River is a tidal estuary from New York Harbor to the Federal Dam at Troy. The tidal flow is significantly higher than the freshwater flow (8,500-14,160 m^3/sec vs. 85-850 m^3/sec at Troy) (Stedfast 1982). There are two floods and two ebbs in a 24-hour interval, which is referred to as a semidiurnal pattern. The moon's distance and phase are the principal factors influencing the tidal amplitude and current velocities within this semidiurnal pattern.

Tidal behavior within any longitudinal segment of the Estuary is the composite effect of ocean tidal amplitude (difference in height at high and low tide), channel configuration, and wave reflection. Ocean tides, which change from maximum amplitude (spring tides) to minimum amplitude (neap tides) and back in a 28-day cycle, are the primary variable. Channel configuration, including width, cross-sectional area, slope, and obstructions, can modify tidal behavior. Significant changes in width can cause reflected secondary waves; complete reflection occurs at the Federal Dam. Variations in freshwater flow and barometric conditions also contribute to changes in amplitude. The interaction of these factors in the Estuary produces a significant variation in the mean tidal amplitude. In fact, tidal amplitude is greater at Troy than it is at the Battery: Battery, 4.4 ft; Storm King, 2.6 ft; and Troy, 4.7 ft. During spring tides the range of high- and low-water elevations is greater, about 5.3 ft at the Battery, 3.1 ft at Storm King, and 5.1 ft at Troy.

4.2.4 Water Temperature

The predominant temperature pattern is the annual cycle of low winter and high summer temperatures. Hudson River temperature varies according to these natural seasonal cycles. Substantial variations in the pattern occur, particularly in the spring and fall. Minimum water temperatures in the vicinity of Poughkeepsie, New York, average approximately 34°F and occur in January and February. Maximum water temperatures in the same area average approximately 77°F and typically occur in August. From April through June, temperatures increase at an average rate of approximately 0.2°F per day and fall at the same rate from mid-September through mid-December.

Although longitudinal variations in temperature during different seasons exist in the Estuary, for much of each year the average difference over the length of the Estuary is only 6–8°F. Upstream, areas change quickly in response to freshwater flow and atmospheric conditions. Downstream, areas are less variable because their larger volumes dilute inflow and dampen fluctuations. Downstream regions warm more slowly in spring and summer than the upriver regions and cool more slowly in the fall. During spring and fall, longitudinal differences may be 10°F or more between fresh water coming into the Estuary in the Albany region and the ocean waters intruding up the river.

The upper Estuary is generally mixed; surface and bottom temperatures vary little in most regions. However, distinct temperature differences occur in the lower estuary when cool, saline waters intrude along the bottom, and fresh water warmed in shallow areas tends to move downstream upon the surface.

4.3 SUMMARY OF CHEMICAL CHARACTERISTICS

4.3.1 Salinity

By definition, an estuary is that portion of a river where fresh water and marine water mix. Although this definition does not allow fixed geographic boundaries, the ultimate upper end of an estuary is that point where tidal effects are no longer present. For the Hudson River this point is the Troy Dam. Within an estuary, salinity influences the distribution and abundance of species and biotic communities along a gradient from "fresh water" to polyhaline or "marine" water.

The "salt front" is a transition zone where fresh water first meets the mixture of fresh and marine waters, traditionally defined as the 0.1 ppt concentration. The salinity zones move longitudinally up- and downstream with fresh water flow, and are also influenced by tidal amplitude and mixing caused by variability in the morphometry of the river. As freshwater flow increases, the area of tidal fresh water expands; as fresh water decreases, the higher salinity zones extend upstream.

High spring flows move the salt front down to the Tappan Zee region (RM 27); summer low flows allow the salt front to intrude toward Poughkeepsie (RM 71). For most years, the salt front remains downstream of the Roseton station. The Indian Point and Bowline Point areas experience seasonal variation from fresh water to mesohaline salinities.

In addition to influencing geographic patterns in salinity, the intrusion of salt water from the ocean brings about stratification of the Estuary. Denser, more saline water follows deeper areas of the Hudson River channel. Irregularities like sills in the river bottom or constrictions in shorelines cause changes in flow direction and velocity, resulting in mixing between fresh- and saltwater layers. The slower flows in shallow shoreline areas, often coupled with inflow from tributaries, bring about lower salinities in shallow shore zones. The intrusion of salt from the ocean into the Hudson River is the primary cause of density-induced circulation in the Estuary. This net, non-tidal movement of water seaward in the upper layer and landward in the lower layer of the salinity-intruded river affects the transport of energy, mass, and plankton through the Hudson River. For example, this phenomenon, coupled with diurnal vertical movement of many fish larvae, is believed to control the location of these early life history stages along the Estuary's longitudinal axis.

4.3.2 Dissolved Oxygen

Dissolved oxygen (DO) concentrations within the Estuary appear to be generally sufficient for the maintenance of healthy aquatic communities. Average regional DO values over the period 1974–1987 indicate low average concentrations in the Albany region (RM 125–152) and the Yonkers region (RM 12–23) (LMS 1989). Only the Yonkers region, however, yielded summer DO values regularly below 4 mg/L, and then only prior to 1983. Highest average DO concentrations were observed in the regions from Kingston through Catskill.

Over the years, average DO concentrations are generally highest from February through April and lowest from July through September. In the Yonkers region, peak DO concentrations typically average approximately 12 mg/L and decrease to about 5 mg/L in the summer. Peak winter DO concentrations tend to be relatively constant at 12–13 mg/L throughout the river. Summer DO values tend to be higher upriver, approximately 7–8 mg/L in the Kingston region, although they are slightly lower (about 6.5 mg/L) in the Albany region.

Analysis of residual DO values (i.e., the difference between the average weekly DO concentrations for the region over the period 1974–1987 and each individual observation from the corresponding week) indicates that the middle Estuary regions are least variable in DO concentration. In the regions from Indian Point through Hyde Park, 95 percent of the DO values fell within approximately 1.6 mg/L of the weekly average. In the more variable Yonkers and Albany regions, 95 percent of the observations fell within 2.3 and 2.5 mg/L, respectively, of the weekly average.

Throughout most of the Estuary, DO differs only slightly from the surface to the bottom. However, in the lower river during low-flow months, distinct differences in DO concentrations between the surface and bottom can occur. This stratification is a result of the intrusion of higher-salinity ocean waters along the bottom.

4.3.3 Nutrients/Toxics

Primary nutrients of interest for the Hudson River estuary include nitrogen, phosphorus, and organic carbon. Most of the nitrogen entering the Estuary comes in the form of nitrates and to a lesser extent, ammonia. Approximately one-half of the total nitrogen entering the Estuary is attributed to wastewater treatment discharges and urban runoff (Fruci and Howarth 1990). Most of the ammonia is found near urban areas and can be attributed to wastewater treatment discharge. At the present time, the availability of nitrogen does not limit primary production in the Estuary. The principal sources of phosphorous in the Estuary include wastewater discharge, urban runoff, and input from the ocean. In saline areas of the Estuary, phosphorous concentrations are typically an order of magnitude higher than in freshwater areas. As with nitrogen, phosphorous does not appear to be limiting to plant growth in freshwater areas and reflects enrichment from artificial sources in saline areas.

Organic carbon inputs provide the primary source of energy to the Hudson River ecosystem (Findlay *et al.* 1991); a phenomenon similar to many other river systems of the world. The combination of high stream discharge and high suspended organic matter concentrations during spring runoff or major storms are responsible for the bulk of the carbon transported in the Estuary. In freshwater areas, much of the organic matter comes in the form of leaf litter, whereas near urban areas, wastewater discharges can become an overriding source. This suspended particulate matter is a major contributor to the high levels of turbidity found naturally within the Estuary. Much of this particulate carbon is consumed by lower trophic levels (zooplankton, benthic macroinvertebrates, etc.) in the Estuary. These, in turn, are the primary source of food, and hence energy, for higher trophic levels including fish.

Principal toxic chemicals in the Estuary include pesticides and herbicides, heavy metals, and other organic contaminants such as polycyclic aromatic hydrocarbons (PAHs) and Polychlorinated biphenyls (PCBs). Sources for these toxicants include point sources (e.g., wastewater discharges), non-point sources (e.g., urban and agricultural runoff), and accidental spills. Many of these compounds exhibit low water solubility and are principally found bound in estuarine sediments where they can remain for decades.

Pesticides and herbicides are not believed to pose significant risk to the Estuary from continued inputs because of improved controls, and sediment contaminant concentrations appear to have declined in the past few decades (CHGE *et al.* 1999). Areas of sediment contamination appear limited to urban areas near New York City. Likewise, concentrations of many heavy metals also appear to be in decline and remaining areas of concern appear largely limited to those near urban or industrialized areas. With the exception of areas near New York City, there does not appear to be a major concern with respect to heavy metals in the Hudson River estuary (CHGE *et al.* 1999).

PAHs, which are products of incomplete combustion, most commonly enter the Estuary as a result of urban runoff. As a result, areas of greatest concern are limited to urbanized areas, principally near New York City. The majority of individual PAHs of concern have declined during the past decade in the lower Estuary and New York Harbor.

PCBs are the principal toxic chemicals of concern in the Hudson River estuary. Primary inputs of PCBs in freshwater areas of the Estuary are from the upper Hudson River near Fort Edward and Hudson Falls, New York. In the lower Estuary, observed PCB concentrations are a result of both transport from upstream as well as direct inputs from adjacent urban areas. As a group, PCBs exhibit low water solubility yet high solubility in lipids. Consequently, PCBs tend to be bound to sediments, and also bioaccumulate and biomagnify once they enter the food chain. This tendency to bioaccumulate and biomagnify results in the presence of PCBs in the tissues of aquatic-dependent organisms. These tissue levels can be many orders of magnitude higher than those observed in sediments and can approach or even exceed levels that pose concern to the environment and to humans who might consume these organisms. Over the past two decades, PCB concentrations in the aquatic organisms from the Estuary have been declining; however, concerns over potential human health and ecological risks remain. Extensive studies and assessments are currently underway to determine the most appropriate means to manage PCB inputs from the upper River.

4.4 SUMMARY OF AQUATIC ECOSYSTEM

4.4.1 Lower Trophic Levels

As previously discussed, energy to drive the Hudson River ecosystem comes principally through inputs of particulate organic carbon that is washed into the Estuary during high flow periods. Primary production by phytoplankton and rooted aquatic plants, which are often the principal energy sources in less-turbid systems, contributes little to the overall energy needs of the Estuary's ecosystem. Naturally high turbidity levels limit phytoplankton production by reducing light penetration and photosynthesis. Further, the recent invasion of freshwater areas of the Hudson by zebra mussels has further reduced phytoplankton production. Rooted aquatic vegetation, especially water chestnut, occurs in dense stands in freshwater areas of the Estuary. However, the importance of these plants to the overall ecosystem is limited by the lack of suitable habitat and high turbidity levels.

Once the particulate organic material enters the Hudson, breakdown begins as a result of bacteria, fungi, and other microorganisms. The resulting detrital complex (organic material and associated living organisms) serves as an important food resource for both pelagic zooplankton and benthic macroivertebrates. Both of these two groups are observed in high concentrations in the Estuary. These pelagic zooplankters, in turn, serve as principal food resources for a variety of larger pelagic zooplankton (e.g., opossum shrimp), larval fish (e.g., the herrings, white perch, and striped bass), and juvenile and adult filter-feeding pelagic fish (e.g., the herrings and bay anchovy). Benthic macroinvertebrates serve as important food resources for a variety of fish, including juvenile striped bass and white perch, as well as many bottom-feeding adult fish including hogchokers and sturgeon.

4.4.2 Fish Community

The Estuary provides at least temporary habitat to a large number of fish species. To date, more than 200 species of fish have been reported from the Estuary. This group includes freshwater species, estuarine residents, anadromous and catadromous species, and marine species, both temperate and tropical. Despite this high species richness, the actual fish community lacks species diversity. This is evidenced by the fact that a very small number of species account for the majority of individuals found in the Estuary. Typically, from 7 to 10 species account for more than 95 percent of individuals in the Estuary. Many of these species have significant commercial and recreational importance to humans. For these species, the Estuary serves as an important spawning and nursery ground.

Most fish spawning occurs in late spring of the year and collections of larval fish are dominated by three herring species (alewife, blueback herring, and American shad), striped bass, and white perch. All of these species are found in abundance throughout the freshwater area of the Estuary. White perch is the only life-long inhabitant of the Estuary, the other four are anadromous species that spend most of their lives at sea and return to their natal estuaries only to spawn. During summer, larval collections are dominated by a single marine species, the bay anchovy, which is abundant in brackish water areas of the Estuary.

In freshwater and low salinity brackish areas of the Estuary, collections of young-of-the-year fish are dominated by the same five species that account for most of the larval fish. In more saline areas, a variety of young-of-the-year marine species can be found which utilize the lower Estuary as nursery habitat. With the exception of white perch, which remains in the Estuary, most of the young-of-the-year of these common species leave the Estuary for ocean waters as water temperatures decline in the fall.

Collections of yearling and older fish in the freshwater areas tend to be dominated by life-long residents of the Estuary. Common species include white perch, spottail shiner, and banded killifish in shallow water areas and white catfish, white perch, and hogchoker near the bottom in deeper areas. In the brackish areas, the yearling and older component of the fish community is dominated by a single species, the bay anchovy, which is found in high abundance throughout the inshore coastal waters of the eastern United States.

Evidence suggests that the fish community presently found in the Hudson River estuary is healthy and consistent with that expected in any similar estuarine system. Several of the species comprising this community, including striped bass and Atlantic silverside, have witnessed substantial increases in population abundance in recent decades as a result of improved water quality and fisheries management, providing further evidence as to the health of this system (CHGE *et al.* 1999).

4.5 LIFE HISTORY CHARACTERISTICS OF SHORTNOSE STURGEON

4.5.1 General Species Overview

Shortnose sturgeon is a member of the sturgeon family, *Acipenseridae*, which occurs in the Northern Hemisphere and has extensive evolutionary history that dates back about 200 million years (Bemis and Kynard 1997). Within North America, shortnose sturgeon inhabit large coastal rivers along the Atlantic Ocean, ranging from the Saint John River in New Brunswick, Canada to the St. Johns River in Florida. Nineteen distinct stocks ranging in size from approximately less than 100 adults in the Merrimack River, Massachusetts, to greater than 38,000 (now 60,000) adults in the Hudson River, New York are recognized (NMFS 1998). Because most shortnose sturgeon adults remain in their natal river or estuary, there is limited interchange between stocks (Kynard 1997). However, individuals have been captured occasionally at sea near the coast. Shortnose sturgeon presumably from the Hudson River have been caught in Sandy Hook Bay, New Jersey (Dovel *et al.* 1992).

Shortnose sturgeon are long-lived, slow maturing fish and the smallest species of sturgeon in North America, with a maximum length in the Hudson River of about 3.5 ft (Dovel *et al*. 1992). The oldest known shortnose sturgeon is a 67-year-old female from Saint John River, Canada; while in the Hudson River the maximum reported age for shortnose sturgeon is 37 years (Gilbert 1989). Age at maturity varies by geographic location. In the Hudson River estuary, male shortnose sturgeon reach sexual maturity at age 3–5 years and females at age 6–7 years (Dadswell *et al.* 1984). The first spawning, however, may follow maturation in males by 1–2 years, while in females spawning may be delayed for up to 5 years (Dadswell 1979a). Spawning appears to be a non-annual event. Based on the percentage of fish examined from August to March that were developing sexually, Dadswell (1979a) suggested that females spawn once every third year and males every other year. Other evidence (annuli of the pectoral ray) suggests a 5- to 11-year interval between spawning (Dadswell 1979a). However, annual spawning has been suggested by tagging studies on the Hudson River that tracked shortnose sturgeon to the spawning grounds in successive years (Dovel *et al.* 1992).

Shortnose sturgeon appear to spend virtually all of their life in deep-water areas of their natal river, and only rarely enter nearby coastal waters (Bemis and Kynard 1997). In general, spawning migrations within the estuary, which can occur in either, or both, the fall and the spring (Kynard 1997), move shortnose sturgeon upriver in deeper channel areas as far as accessible habitat permits, often exceeding 125 mi from the mouth of their natal estuaries. Depending on latitude, spawning occurs from late winter to mid-spring when river temperatures increase to about 48ºF and spawning usually ceases at 54–59ºF (Kynard 1997). The duration of spawning activity ranges from a few days to 2–3 weeks. River channels with gravel substrate and moderate bottom water velocities seem characteristic of spawning habitat preferred by shortnose sturgeon (NMFS 1998).

Shortnose sturgeon are broadcast spawners with external fertilization of eggs. Ripe eggs and fertilized eggs have diameters of 3.0–3.2 mm and 3.5 mm, respectively (Dadswell *et al.* 1984; Buckley and Kynard 1981). The eggs are demersal and adhere to objects on the river bottom within minutes of fertilization. Eggs hatch 13 days after fertilization at temperatures between 46 and 54ºF. At 63ºF, hatching occurs in 8 days (Buckley and Kynard 1981). Upon hatching, larvae are 7.3–11.3 mm long (Taubert 1980; Anonymous 1981 in Dadswell *et al.* 1984; Buckley and Kynard 1981). Research on larval behavior indicates that hatchlings are photonegative and vigorously seek cover under any available structure immediately after hatching (Richmond and Kynard 1995).

During the first 1–2 days following hatching, larvae denied or dislodged from cover will exhibit "swim-up and drift" behavior, which in the wild allows them to move short distances to seek available cover. Yolk-sac larvae continue to seek bottom cover for about a week, but after 1–2 days post-hatch their movements are predominantly horizontal along the bottom (Richmond and Kynard 1995). At 8–12 days post-hatch, larvae have well-developed eyes, a mouth with teeth and fins that enable them to swim normally (Kynard 1997). In laboratory tests, larvae of this age were photopositive, nocturnally active, and preferred the deepest water available (Richmond and Kynard 1995). Ten-day-old larvae reportedly attempt to remain on the bottom or place themselves under any available cover (Pottle and Dadswell 1979a; Washburn and Gillis Associates 1980). At this age (9–12 days post hatch), larvae are 15 mm long total length (TL), the yolk sac is completely absorbed, and the fry are feeding on zooplankton (Buckley and Kynard 1981; Washburn and Gillis Associates 1980). By about 14–17 mm TL, shortnose sturgeon, resembling miniature adults, become photopositive and leave cover to swim in the water column, although remaining bottom oriented. In the wild, larvae of this size probably migrate downstream (Richmond and Kynard 1995).

Early growth is rapid. Shortnose sturgeon larvae average approximately 18 mm (0.7 in. TL at the end of May and from 125 to 130 mm (4.9 to 5.1 in.) by the end of July. Young shortnose sturgeon grow to 300 mm (11.5 in.) TL by the end of their second summer (Dovel *et al.* 1992), feeding on amphipods and dipteran larvae. Insect larvae and small crustaceans predominate in the diet of juveniles while adults feed primarily on small mollusks (Dadswell *et al.* 1984). After about the third year of life, growth slows considerably. Dadswell *et al.* (1984) reported a maximum size of approximately 900 mm (35 in.) at age 40, but shortnose sturgeon over 990 (39 in.) have been captured in the Estuary (Hoff and Klauda 1979).

4.5.2 Distribution and Habitat Use in the Hudson River Estuary

Although shortnose sturgeon move considerable distances within the Estuary, they rarely appear to migrate to the ocean or to neighboring systems. Within the Estuary, shortnose sturgeon display complex migratory behavior with non-spawning and spawning adults using different habitats and displaying different migratory behavior (Bain 1997). From late spring through early fall, most adult shortnose sturgeon are distributed in deep, channel habitats of the freshwater and brackish reaches of the Hudson River estuary. As water temperatures decline in the fall, adult shortnose sturgeon typically concentrate in a few deeper overwintering areas, particularly near Kingston (RM 87) for pre-spawning adults and near Haverstraw (RM 33-38) for non-spawning adults (Figure 1-1) (Dovel *et al.* 1992; Bain 1997).

As early as the first week of April, adult shortnose sturgeon reach the spawning grounds between Coxsackie and Troy (RM 118–148) (Figure 1-1). Spawning occurs from late April to early May (Dovel *et al.* 1992). After spawning, adults move downriver to feed and disperse over the tidal portion of the Hudson River estuary, but are primarily south of Kingston (Bain 1997). Non-spawning adults are also distributed in this portion of the Estuary after migrating upstream from their overwintering areas in the spring.

Differentiation between shortnose sturgeon and the closely related Atlantic sturgeon (also found in the Estuary) at the larval stage is difficult and uncertain, and attempts at identification are largely restricted to years since 1991. Consequently, the exact location of shortnose sturgeon larvae within the spawning and nursery areas of the upper Estuary cannot be precisely determined. However, available information can be used to draw reasonable inferences. The seasonal and spatial distribution of yolk-sac and post yolk-sac sturgeon larvae collected over the 24-year period is shown in Figure 4-1. Two distinct distributions of yolk-sac larvae are evident. One occurs upstream above about RM 120 during a brief period in early to mid-May, the other extends from approximately RM 48 to RM 110 in the Estuary and occurs over a more protracted period between mid-May and early July. These upriver and downriver groupings of yolk-sac larvae are consistent with the known seasonal timing and location of spawning for shortnose sturgeon and Atlantic sturgeon, respectively. The sturgeon post-yolk-sac larvae collected also reflect this bimodal distribution, but are shifted slightly downriver and one to two weeks later in the season, as would be expected for older larvae (Figure 4-1). These patterns suggest that shortnose sturgeon larvae are found principally in the upper-most areas of the Estuary, well away from the intakes of the six power plants considered in this EA.

In light of the known distributions of spawning adults described above, the long-term average distributions of sturgeon larvae suggest that the young of the two sturgeon species may occupy largely non-overlapping (allopatric) ranges during their first summer of growth. By late fall and early winter, most juveniles of both species occupy brackish water overwintering areas located downriver, with most shortnose sturgeon occupying the area between about RM 34–39 (Dovel *et al.* 1992). There is no evidence that juvenile shortnose sturgeon move out of the lower Estuary into coastal marine waters (Bain 1997).

4.5.3 Status and Trends in Hudson Population

The population of shortnose sturgeon in the Hudson River estuary appears to have increased over the past few decades and the Estuary presently contains the largest discrete population of shortnose sturgeon reported anywhere. Evidence for this apparent population increase comes from two independent sources. First, the annual estuary-wide monitoring conducted by the Utilities provides a relative measure of population abundance. This program dates back to 1974 and encompasses the entire Estuary from the Battery at the southern tip of Manhattan (RM 0) to the Federal Dam at Troy (RM 152). Data compiled from this monitoring program show that the catch rates of shortnose sturgeon have been increasing since 1985, especially in the beam trawl and epibenthic sled samples (Figure 4-2).

The second, independent source of information suggesting population increases in the Hudson River population of shortnose sturgeon comes from mark-recapture studies that provide estimates of absolute population sizes within the Estuary. In the late 1970s, Dovel (1979) estimated the shortnose sturgeon population in the Hudson River estuary at 13,844 fish. In the 1990s, researchers from Cornell University conducted a similar mark-recapture study (Bain *et al.* 1995, 1998). Using techniques identical to those of Dovel, these researchers provided a preliminary population estimate of 38,024 adults (Bain *et al.* 1995). Subsequently, this estimate was refined to 56,708 individuals based on additional data suggesting a four-fold increase in population size since the 1970s (Bain *et al.* 1998). Further, refined analytical techniques indicate that the most appropriate population estimate based on the Cornell study is 61,057 fish, 1-year-old and older (Bain *et al.* 1998). These estimates reflect those fish in the overwintering and spawning concentration areas and, thus, are likely just a subset of the total adult population. Additionally, because shortnose sturgeon do not appear to spawn every year, the majority of the population may be non-spawners and, thus, not included in this population estimate. Available data appear to indicate that the population of shortnose sturgeon in the Hudson River estuary is healthy and that this species is reproducing and adding young fish to the Hudson population (Bain *et al.* 1998).

5. ENVIRONMENTAL CONSEQUENCES

The purpose of this section is to assess the potential environmental consequences of the proposed action with particular emphasis on the cumulative impacts considering all other known sources of stress on this population.

5.1 NATURE OF POTENTIAL EFFECTS

The operation of power plants, such as the two that are the focus of this assessment (and the other power plants considered as part of the cumulative impact analyses), requires withdrawal of large quantities of water for cooling purposes, and the subsequent discharge of this cooling water, at an increased temperature, back to the source waterbody. The use of cooling water could cause mortality of shortnose sturgeon from entrainment and impingement at the cooling water intake, or from effects of the discharge. The nature of these potential effects is described below.

5.1.1 Entrainment

Along with the water used for condenser cooling, organisms smaller than the intake screen openings (usually 0.25- to 0.5-in. mesh) can be drawn into the system, a process called entrainment. Planktonic organisms are susceptible to entrainment because their small size and limited swimming ability reduce the potential for escape from the entrained water mass and allow passage through the mesh of the traveling screens. Entrained fish are typically limited to the younger life stages of fish (eggs and larvae) and this is the case for shortnose sturgeon. Any entrained fish eggs and larvae pass through the circulating pumps and condenser tubes along with the cooling water. The cooling water and any entrained fish eggs and larvae then enter the discharge canal or conduit for return to the Estuary. During their passage through the plant, entrained individuals experience a variety of stresses, some of which may cause death. Survival rates for fish eggs and larvae entrained by power plants depend on the species' hardiness as well as their responses to thermal stresses. Entrainment survival rates for relatively hardy species, such as striped bass, white perch, and Atlantic tomcod, at mid-Hudson River power plants generally exceed 70 percent (EA 1989).

5.1.2 Impingement

To keep condensers from clogging with solid materials and biota, power plant cooling water intake systems use a combination of large- and finer-mesh screens. Typically, the large-mesh screens or bar racks (2–3 in. slot width) are fixed in place while the finer-mesh screens can move to facilitate cleaning. These movable screens are called traveling screens. As the water passes through these screens, organisms larger than the mesh openings, such as larger invertebrates and fish, can be impinged against the screens. Owing to their more limited swimming abilities, most fish impinged are less than 1 year old. Various screenwash systems are employed for periodically removing impinged fish from the screens and returning them to the Estuary. Continuous rotation of traveling screens, as employed at each of the Hudson River power plants, reduces the amount of time the fish are in contact with the screen and substantially increases post-impingement survival. The survival rate for impinged fish is species specific, varies with size and season, and depends on several other power plant-related factors, such as intake velocity, plant design, and operating conditions. For hardy species (e.g., striped bass and Atlantic tomcod), impingement survival is generally high (>50 percent for conventional traveling screens [Muessig *et al.* 1988]). At Roseton Generating Station, there are six conventional traveling screens and two dual-flow, band-type screens, which are similar but not identical to modified Ristroph-type screens. All the traveling screens at Danskammer Point are of the conventional type.

5.1.3 Discharge Effects

The discharge of heated cooling water has the potential to affect species of fish in the Estuary. At many power plants, various biocides, such as chlorine and bromine, are used to keep the cooling water system clean and free from biofouling, which could adversely affect plant performance. Some residual amounts of these biocides are then released back into the environment along with the cooling water. In addition, exposure to heated effluent can adversely affect aquatic organisms in the source/receiving waterbody if their thermal tolerance levels are exceeded. Discharged amounts of biocides and heat are limited by SPDES permits, which are established to protect aquatic life and enforced through discharge monitoring requirements. Neither the Roseton nor Danskammer Point power plants discharge chlorine or other biocides into the Estuary.

5.2 IMPACT OF PREFERRED ALTERNATIVE — IMPLEMENTATION OF THE CONSERVATION PLAN

An assessment of the potential take of shortnose sturgeon as a result of each of these three types of power plant effects is presented below. This assessment addresses the potential take at all six power plants located along the mid-Hudson River estuary even though the focus of this Plan is on only two plants, Roseton and Danskammer Point. The information for the other plants will be addressed as part of the cumulative impact assessment.

5.2.1 Estimates of Entrainment

Due to their life-history characteristics, the Hudson River population of shortnose sturgeon has low vulnerability to entrainment effects from operation of any of the six power plants discussed in this chapter. Shortnose sturgeon spawn in the northern most areas of the Estuary. In addition, shortnose sturgeon eggs are demersal and adhesive and, upon hatching, yolk-sac larvae and larvae seek cover on the bottom. As a result, the eggs and larvae of shortnose sturgeon are located primarily upstream of RM 110, well upriver of any of the six power plant intakes. Consequently, few entrainable life stages of shortnose sturgeon occur in the vicinity of any of these power plants. The preference of shortnose sturgeon larvae for deeper waters and their benthic orientation, coupled with the fact that the intakes of these power plants are located along the shore, additionally reduces the possibility of their entrainment at these power plants.

Because of the concerns over the potential effects of entrainment mortality on fish populations in the Estuary, entrainment-monitoring studies were conducted at each of the power plants over the 16-year period from 1972 to 1987. Sampling methods for these studies are detailed in Appendix A, Tables A-1 through A-5. Especially intensive monitoring for entrainment abundance was conducted at each power plant from 1981 through 1987. This intensive monitoring entailed sampling nearly 24 hours per day, on 4–7 days per week, over the 10- to 12-week long peak entrainment season (spring) each year.

During entrainment sampling, very few entrainable-size (i.e., small enough to fit through the wire mesh of the traveling screens) shortnose sturgeon were collected from any of the power plants (Table 5-1). Only at Danskammer Point were any (4) shortnose sturgeon larvae identified in entrainment samples, all in 1984. A small number (4) of sturgeon yolk-sac and post yolk-sac larvae (species unidentified) were also collected in entrainment samples, again all at Danskammer Point and in 1983 and 1984. However, because the early life stages of Atlantic and shortnose sturgeons are very similar in appearance, definitive identifications were not made and, thus, they could have been of either species. The occurrence of shortnose sturgeon larvae in 1984 might be explained by the fact that the highest single-day freshwater flows during both May and June (encompassing the larval period for shortnose sturgeon) since 1974 occurred that year.

The total number of shortnose sturgeon larvae collected at all 6 power plants over the entire 16-year study period was between 4 (assuming all unidentified sturgeon were Atlantic sturgeon) and 8 (assuming all unidentified sturgeon were shortnose sturgeon). Given the geographic distribution of the eggs and larvae of this species, it is unlikely that there will be any biologically significant entrainment of shortnose sturgeon at either plant considered in this Plan if environmental conditions do not vary.

The low vulnerability inferred from distributional information and the direct evidence that very few shortnose sturgeon larvae were collected in the intensive entrainment monitoring programs suggest that the potential for entrainment of shortnose sturgeon at either Roseton or Danskammer Point is low. Further, detailed entrainment survival studies conducted on other species suggest that for all but the most delicate species (e.g., anchovies and herrings), most larvae entrained are returned to the Estuary alive (Cannon *et al.* 1978; Jinks *et al.* 1981; EA 1989). Thus, it seems reasonable to presume that the few shortnose sturgeon larvae entrained are also likely to be returned to the Estuary alive.

5.2.2 Estimates of Impingement

While shortnose sturgeon juveniles and adults are found throughout the Estuary, only one of the six power plants, Bowline Point, is located near known concentration areas. However, Bowline Point withdraws water from a man-made embayment called Bowline Pond and the intakes are set back over 2,200 ft from the shoreline, well away from channel congregation areas. Bowline Point's intake is also protected by a barrier net during much of the year. Based on the distribution of shortnose sturgeon concentration areas, juvenile and adult shortnose sturgeon are unlikely to frequent the area of the five power plants and thus appear to have relatively low vulnerability to impingement at any of these power plants. Further, juvenile shortnose sturgeon prefer the deeper waters of channel areas, where they are found on the bottom. This deep benthic orientation, coupled with the fact that the intakes of these power plants are located along the shore, further reduces vulnerability to impingement at any of these five power plants.

Because of concerns over potential effects of power plant impingement on fish populations in the Estuary, extensive impingement monitoring studies have been conducted at each of the power plants since the early 1970s. Sampling methods for these studies are detailed in Appendix A, Tables A-6 through A-10. In general, weekly, 24-hour sampling to examine the abundance and species composition of impinged organisms has occurred annually at Bowline Point, Lovett, Roseton, and Danskammer Point. At Indian Point, impingement abundance and species composition were monitored daily until July 1981 and thereafter for 110 days per year on a seasonally stratified, randomly selected schedule. Impingement sampling at Indian Point was discontinued in 1991 following the installation of modified Ristroph-type traveling screens (Section 2.1.3), which are specifically designed to mitigate harm to impinged fish.

Since the start of impingement monitoring in 1972, only 63 shortnose sturgeon have been collected in impingement samples from all six power plants over the 26-year interval of available data (Table 5-2). Of these, 29 were collected at Roseton or Danskammer Point. No strong seasonal pattern in the collection of this species is evident at any of the power plants (Figure 5-1). These counts represent the total number of shortnose sturgeon documented as impinged at each power plant over all sampling periods. Sampling procedures require that all sturgeon alive at the time of collection be carefully returned to the Estuary after being measured. The condition of some of the individuals collected (i.e., degree of decay) indicates that at least some of those collected were dead prior to collection. Available length frequency data collected on these impinged individuals indicates that the majority were between 200 and 700 mm long (Figure 5-2; Appendix A, Table A-11) and were likely between 2 and 15 years of age based on age-length plots presented by Bain *et al.* (1998).

To estimate the total number of shortnose sturgeon impinged at the six existing power plants, the impingement monitoring results were adjusted up to account for periods not sampled, as described in Appendix A.2. This adjustment yields an estimate of total shortnose sturgeon impingement of 275 individuals, or an average of just over 10 per year across all six power plants during the past 27 years (Table 5-3). Estimated impingement rates of shortnose sturgeon have averaged 7.5 individuals per year over the past 10 years.

Estimates and average rates of the total number of shortnose sturgeon estimated to have been impinged at each power plant are:

Power Plant	1972–1998 Total	1972–1998 Average No. Impinged/Year	1989–1998 Total	1989–1998 Average No. Impinged/Year
Bowline Point	23	0.9	0	0
Lovett	0	0	0	0
Indian Point Unit 2	37	1.4	8	0.8
Indian Point Unit 3	26	1.0	8	0.8
Roseton	49	1.8	15	1.5
Danskammer Point	140	5.2	44	4.4
Total	275	10.2	75	7.5

Given that the future operation of Roseton and Danskammer Point is expected to be similar to that observed in the past decade, it is reasonable to expect that impingement of shortnose sturgeon juveniles and adults in the near-term future will average less than 2 per year at Roseton and less than 4.5 per year at Danskammer Point. Based on these data, NMFS concludes that an annual incidental take of shortnose sturgeon through impingement of less than 10 at Roseton and 20 at Danskammer Point, calculated as a 5-year running average, is both achievable and will not jeopardize the continued recovery of the shortnose sturgeon population in the Hudson River estuary.

It is important to recognize that many impinged fish survive once returned to the Estuary such that lethal take will be considerably lower. Each of the Hudson River Utilities have conducted impingement viability studies at their respective intakes and have demonstrated that the majority of the species impinged have moderate to high survival rates. Hardier species are likely to exhibit extremely high survival after impingement (Muessig *et al.* 1988; Fletcher 1990). Shortnose sturgeon are relatively hardy and resistant to physical stresses similar to those encountered in power plant impingement (Bain 1999, personal communication; O'Herron 1999, personal communication; Kynard 1999, personal communication). During recent intensive trawling of the Estuary to study shortnose sturgeon, the sampling team from Cornell University collected and handled more than 7,000 shortnose sturgeon without a single reported mortality. This program included capture by trawl, removal of the individuals from the water and the net, measurement and weighing of individuals, and insertion of a tag—the combined effect of which could be expected to induce greater stress on the sturgeon than impingement and subsequent return to the Estuary. The lack of mortality associated with this trawling effort suggests that impingement mortality could be similarly low and the majority of those shortnose sturgeon impinged alive will be returned to the Estuary unharmed with the proposed intake screen operation at each power plant. Under a conservative assumption of 20 percent impingement mortality, total lethal take of shortnose sturgeon from impingement would be expected to average less than 1 individual per year at either Roseton or Danskammer Point. Annual lethal take of shortnose sturgeon from impingement under the proposed 5-year running average permit limit would average approximately 2 at Roseton and 4 at Danskammer Point.

5.2.3 Evaluation of Cooling Water Discharge Effects

As previously noted, power plants have the potential to adversely affect fish populations through the discharge of cooling water containing biocides and waste heat. While current SPDES permits allow the use of chlorine to prevent biofouling of the cooling water system at both Roseton and Danskammer Point, such biocides are not needed and have not been used over the past 25 years, owing to the naturally high turbidity levels in the Estuary. Further, there is no reason to expect that they will be needed any time in the future. Consequently, there is no potential that any discharge of these chemicals from either Roseton or Danskammer Point will adversely affect shortnose sturgeon.

The slightly heated water discharged (typically 10–20ºF above ambient) from these operating power plants has a lower density than that of the ambient water. As a result, the thermal plumes produced by these discharges float and highest temperatures are limited to areas near the surface. Since shortnose sturgeon are a benthic species, their potential for exposure to elevated temperatures resulting from cooling water discharges in the Estuary appears to be minimal. Further, fish, in general, are known to detect and avoid potentially lethal water temperatures (Meldrim *et al.* 1974; Neill and Magnuson 1974; TI 1976; EA 1978) suggesting that shortnose sturgeon will swim away in the unlikely event that they are exposed to elevated, potentially detrimental water temperatures. Recent hydrothermal modeling for Roseton revealed that the thermal plume from this plant (as defined by a 4°F temperature increase) occupies 8 percent or less of the cross-sectional area of the Estuary at this location (CHGE *et al.* 1999). Although not specifically modeled, it is reasonable to assume that the thermal plume from Danskammer Point (a smaller power plant) would occupy even a smaller area. Consequently, there is ample area for shortnose sturgeon to move up- and downstream without encountering any elevated temperatures from either plant.

In addition, four of the six power plants (Bowline Point, Indian Point Units 2 and 3, and Roseton) have high velocity diffusers on their cooling water systems at the point of discharge to maximize the rate of mixing of heated discharge waters with the ambient estuarine water. As a result, the heated effluent is rapidly diluted suggesting that little exposure of aquatic organisms to elevated temperatures occurs. Based on the above assessment, the risk is very low that cooling water discharges from either of the two power plants considered in this Plan will adversely affect any shortnose sturgeon in the Estuary.

5.2.4 Assessment of Other Sources of Stress

In addition to cooling water withdrawals, other factors can affect the shortnose sturgeon population. Each of these is discussed below.

5.2.4.1 Biological Monitoring Program Collections

There are presently four distinct surveys ongoing as part of the SPDES-required biological monitoring for the Utilities. Three of these surveys have been conducted annually since 1974; the fourth has been conducted annually since 1985. The exact scope of the SPDES-required monitoring is negotiated on an annual basis between the Utilities and NYSDEC. However, consistency in the methods and coverage of sampling is considered highly desirable for assessing long-term population trends, and it is likely that they will continue with essentially the same scope for some time. Thus, the results of these programs can be used to project the likely takes of shortnose sturgeon from required biological monitoring in the future. These takes, which are addressed under a section 10 of the ESA Scientific Research Permit Application, are included as part of a cumulative assessment of the effects of cooling water withdrawals. These projections are discussed below.

Longitudinal River Ichthyoplankton Survey

The Longitudinal River Ichthyoplankton Survey, or Long River Survey, is designed to monitor the distribution and abundance of fish eggs and larvae in the Estuary during and immediately following the spring and early summer spawning seasons. This survey has been conducted annually since 1974 with only minor modification in the temporal and spatial extent of coverage (Appendix A, Table A-12).

Owing to their demersal and adhesive nature, no shortnose sturgeon eggs have been documented from these surveys. A total of 56 larvae identified as shortnose sturgeon were collected over the 25 years of available data (Appendix A, Tables A-13 and A-14). In addition, 126 sturgeon larvae were collected that were not identified to species and, thus, could have been either shortnose or Atlantic sturgeon. Using the proportion of total identified sturgeon larvae found to be shortnose sturgeon, the unidentified larvae would be expected to contain an additional 46 shortnose sturgeon. Therefore, an estimated total of 102 shortnose sturgeon larvae were collected. However, the actual number of larvae collected could range from 56 to 186 depending on the species composition of those not identified to species. Over the entire 25-year period, these collections averaged approximately 4 larvae per year. Over the past 10 years (1989-1998), catch rates of shortnose sturgeon larvae have been slightly higher, but still average fewer than 6 per year.

In addition to the collection of larval shortnose sturgeon, older sturgeon were occasionally collected in the Long River Survey. Over the 25-year period from 1974 through 1998, a total of 87 yearling and older shortnose sturgeon were also collected in the Long River Survey, for an average of just over 3 per year. Over the past 10 years, catch rates of these older sturgeon have been higher, averaging 6 per year, most likely a reflection of higher population sizes. Beginning 1989, the condition at release was recorded for all yearling and older shortnose sturgeon collected in this survey. These data indicate that all 60 individuals collected over this period were released alive.

Under the presumption that the Long River Survey will continue into the future, it is reasonable to assume that the take of shortnose sturgeon larvae in this survey should average approximately 6 per year. Since the identification of larvae to species requires microscopic examination, all materials collected in this program (including any shortnose sturgeon larvae) are preserved in formalin and returned to the laboratory for subsequent examination. In addition, there would be a collateral collection of yearling and older sturgeon in the same nets at an average rate of 6 per year. However, should the population in the Estuary either increase or decrease, then the take of these species could be either higher or lower. It is expected that all of these older individuals would be returned to the Estuary unharmed.

Fall Shoals Survey

The Fall Shoals Survey is designed to monitor the distribution and abundance of young fish in areas of the Estuary deeper than 10 ft during summer and fall. It has been conducted annually since 1974, although there have been significant improvements in the gear and study design over the years (Appendix A, Table A-12). Most notably for shortnose sturgeon was the change from an epibenthic sled to a beam trawl in 1985. This new gear more effectively sampled bottom-oriented species, including shortnose sturgeon.

A total of 466 shortnose sturgeon have been collected in the Fall Shoals Survey since 1974 or an average of just over 18 per year (Appendix A, Tables A-13 and A-14). Most of these were collected after the change to the beam trawl in 1985 when the catch rates of shortnose sturgeon averaged just over 31 per year. Beginning 1989, the condition at release was recorded for all but one of the shortnose sturgeon collected in this survey. These data indicate that all 383 individuals for whom information exists were released alive.

Under the presumption that the Fall Shoals Survey will continue into the future, it is reasonable to expect that the take of shortnose sturgeon in this survey should average 30–40 per year with little associated sampling mortality. However should the population in the Estuary either increase or decrease, then the take of this species could be either higher or lower.

Beach Seine Survey

The Beach Seine Survey is designed to monitor the distribution and abundance of young fish in the shallow (<10 ft) waters of the Estuary. This survey has remained fairly consistent in design since its inception in 1974, with the exception of a reduction in seasonal coverage and survey frequency (from weekly to biweekly) in the early 1980s (Appendix A, Table A-12).

Shortnose sturgeon prefer the deeper waters of the Estuary and this preference is reflected in the fact that only one shortnose sturgeon was captured in the Beach Seine Survey over 25 years of sampling (Appendix A, Table A-13). Under the presumption that the Beach Seine Survey will continue into the future, it is reasonable to expect that the take of shortnose sturgeon in this survey would be extremely rare, with little, if any, associated sampling mortality.

5.2.4.2 Commercial Fishing

The Hudson River estuary is home to an active commercial fishery for American shad. This shad fishery occurs during the spring spawning migrations when this species moves from the ocean up into freshwater areas of the Estuary where spawning occurs. Soon after spawning, the adults return to the ocean where they remain until the next spawning season.

From April through June of each year, commercial fishing occurs for this species through the use of gill nets. Typically, anchored gill nets are used in downstream areas (Haverstraw Bay and Tappan Zee) whereas drift gill nets are used in upstream areas north of the Hudson Highlands.

As this fishing gear is non-selective, other species of fish, including shortnose sturgeon, are often collected along with the shad. These non-target fish are returned back to the Estuary. However given the stress associated with such capture, is likely that many do not survive. While the NYSDEC presently monitors this fishery, including coincidental by-catch of non-target species, estimates of the total annual take of shortnose sturgeon from this commercial fishing activity is not available. Dadswell (1979), in his assessment of the potential effects of power plant operations on the shortnose sturgeon population in the Estuary, estimated that the annual take of shortnose sturgeon by commercial shad fishermen was in the range of 100 per year.

5.2.4.3 Other Stressors

In addition to the effects of cooling water withdrawals and commercial fishing described above, the shortnose sturgeon population in the Hudson River estuary is potentially subject to a variety of other stressors including dredging, habitat destruction, toxic chemicals, boating, and recreational fishing. To date, the effects of each of these potential stressors on the shortnose sturgeon population have not been quantified. While it is unlikely that any of these stressors significantly affects the health of the population as a whole, each must be considered as part of the cumulative impact assessment on shortnose sturgeon.

5.2.5 Biological Significance of Cumulative Impacts of Preferred Alternative

The purpose of this section is to evaluate the significance of the entrainment and impingement of shortnose sturgeon at Roseton and Danskammer Point on population abundance and the potential for recovery of the Hudson population to the point that listing under ESA would no longer be necessary. While the focus of this EA is solely on the potential effects of cooling water withdrawals at Roseton and Danskammer Point on shortnose sturgeon, these effects must be considered against the cumulative effects of all other sources of potential stress on the population including that from other power plants, biological monitoring, habitat destruction, toxic chemicals, commercial and recreational fishing, and other stressors.

A total of only 4, or possibly 8 including unidentified sturgeon larvae, shortnose sturgeon larvae were collected in the extensive entrainment monitoring conducted at Danskammer Point. No shortnose sturgeon larvae were collected at Roseton over a 16-year study period (1972-1987). Further, no shortnose sturgeon larvae were collected at any of the other four mid-Hudson power plants over this same period. As previously discussed, the low vulnerability of shortnose sturgeon larvae to entrainment can be attributed to their spawning location and demersal behavior relative to the withdrawal zones of the shoreline intake locations. In addition, spawning and larval nursery areas for this species occur many miles north of these power plants and well outside the influence of their cooling water withdrawals. Consequently, it is likely that entrainment of this species at either Roseton or Danskammer Point in future years will remain a rare event and most probably only occur during unusual environmental conditions (e.g., extreme high flows).

The extremely low number of shortnose sturgeon larvae likely to be entrained at the Roseton and Danskammer Point, many of which are likely to be returned to the Estuary unharmed, is likely to have little effect on the shortnose sturgeon population. This conclusion can be reached even when these potential losses are combined with the small collection of larvae as part of the scientific monitoring program (averaging 6 per year) and the potential for entrainment at the other four mid-Hudson power plants. While precise estimates of annual egg production for Hudson River shortnose sturgeon are not available, data from other systems suggest that it may be in the range of 100,000 eggs per female (Dadswell 1979a). The magnitude of entrainment of shortnose sturgeon is small compared to the annual production of young from even a single female and, thus, poses little risk to the health and continued recovery of this species' population in the Estuary.

Based on extensive monitoring data collected from 1972-1998, it is estimated that the number of shortnose sturgeon collected as a result of impingement at Roseton and Danskammer Point should average approximately 6 individuals per year and should not exceed 10 individuals at Roseton and 20 individuals at Danskammer Point, based on a 5-year running average. On average, an additional 1-2 shortnose sturgeon are projected to be impinged at the other four mid-Hudson plants combined. Most of these would be fish less than 8 years old, and all evidence suggests that the vast majority of these would be returned to the Estuary unharmed. Further, an average 40–50 shortnose sturgeon are expected to be collected annually in the biological monitoring program should that continue in its present form. Virtually all of these are expected to be returned to the Estuary unharmed. Total loss of shortnose sturgeon from all these collections should average less than 10 individuals each year. This annual collection of shortnose sturgeon from all Utility-related sources is small compared to a total population size of more than 60,000 shortnose sturgeon age 1 and older estimated to be in the Estuary at present (Bain *et al.* 1998). This estimated annual collection is also small compared to the annual catch of shortnose sturgeon in commercial shad fishing nets in the Estuary, estimated to be in the range of 100 per year (Dadswell 1979b). Most of these commercial fishing takes are expected to be lethal. Based on this information, it is clear that the incremental mortality imposed on the population by the continued operation of the two power plants likely poses little risk to the health and continued recovery of the population of this species in the Hudson River estuary even when considered together with all other sources of potential take.

Another approach to assessing the effects of stressors on biological populations is to monitor the health and condition of the population of a period of time during which the population is subject to that stress. The resulting changes observed on the population provide a measure of the effects of all sources of stress on the population including that of the stress of interest.

As discussed in Section 3.5.3, the shortnose sturgeon population has significantly increased in the Estuary over the past 20-year period to the point that it is now widely considered to be in very safe condition and more than six times the level considered to have a very low risk of extinction

(Bain *et al.* 1998). This pattern provides strong evidence that the cumulative effects of all man-induced stresses over this period have not been sufficiently detrimental so as to prevent this recovery. During this time both Roseton and Danskammer Point, as well as the other four mid-Hudson power plants, were withdrawing cooling water at levels comparable to what is being proposed for the future. In fact, it appears that the collection of shortnose sturgeon as a result of impingement was actually higher when the population was much lower than it is today. Reasons for the present lower impingement rate of shortnose sturgeon are unknown, but might reflect a net upstream movement of the population allowed by improved water quality in the extreme upstream end of the Estuary near Albany. Thus, it is reasonable to conclude that issuance of a permit to Roseton and Danskammer Point allowing the incidental take shortnose sturgeon at levels expected to be in the range of previous years, will not impede the continued recovery of this species in the Hudson River estuary.

5.3 ALTERNATIVE 2 – ADDITION OF CLOSED CYCLE COOLING

Addition of cooling towers at Roseton and Danskammer Point would result in a reduction in cooling water withdrawals by approximately 95 percent. Such reductions could be expected to lead to reductions in the number of shortnose sturgeon impinged at each facility. Given the rare occurrence of shortnose sturgeon early life stages in the vicinity of either plant, reductions in the numbers of larvae entrained associated with cooling tower installation are difficult to predict.

However, any reductions in the potential collections of shortnose sturgeon from cooling water withdrawals that result from retrofitting either plant with cooling towers must be weighed against the cost and environmental consequences of such an action. As previously discussed, installation and operation of cooling towers at Roseton and Danskammer Point would have significant environmental impacts including:

- Vegetation clearing
- Visual impacts
- Need for make-up power
- Drift of salts and chemical pollutants
- Noise impacts
- Pollutant concentrations in tower blowdown
- Sludge

The consequences of such impacts must be weighed against the relatively small reductions in the annual take of shortnose sturgeon at both facilities. In addition, sufficient CHGE-owned land does not presently exist for installation of cooling towers at Danskammer Point. Additional land would have to be acquired, potentially affecting local private owners. Finally, installation of cooling towers at Roseton is estimated to cost $120 million, not including annual maintenance and upkeep.

As previously discussed, implementation of the CHGE's Conservation Plan appears sufficient to ensure that the continued operation of the cooling water intakes at Roseton and Danskammer Point will not likely jeopardize the continued recovery of shortnose sturgeon in the Estuary.

Thus, the additional protection afforded by installation of cooling towers appears unnecessary given the large economic costs and coincident environmental impacts to the Hudson River valley.

5.4 ALTERNATIVE 3 – NO ACTION

Although issuance of a Section 10 Incidental Take permit is not required for either Roseton or Danskammer Point, in the absence of the proposed Section 10 permit, the enforceability, under the Endangered Species Act, of the measures described in Conservation Plan would not be assured. Without such assurance, it is possible that the number of shortnose sturgeon impinged at Roseton and Danskammer Point, and the stresses associated with that process, could be slightly higher than under the Preferred Alternative.

6. FINDING OF NO SIGNIFICANT IMPACT

TO BE PREPARED AFTER THE COMMENT PERIOD

7. LIST OF AGENCIES/PERSONS CONSULTED

The following is a list of agencies and persons that were contacted during the course of preparing this EA:

Dr. Mark Bain	Cornell University
Dr. Boyd Kynard	United States Fish and Wildlife Service
John O'Herron	O'Herron and Associates
Edward Radle	New York State Department of Conservation
Dr. Michael Dadswell	Acadia University

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FIGURES

TABLES

TABLE 5-1 ACTUAL NUMBER OF SHORTNOSE STURGEON (SNS) COLLECTED DURING ENTRAINMENT SAMPLING AT SIX HUDSON RIVER POWER PLANTS, 1972-1998

	Bowline	**Lovett**	**Indian Point Unit 2**	**Indian Point Unit 3**	**Roseton**	**Danskammer Point**	**Annual Total**
1972	NS	NS	NR	Not Operational	Not Operational	NS	---
1973	NS	NS	NR	Not Operational	NS	NS	---
1974	NS	NS	NR	Not Operational	0	0	0
1975	0	0	NR	Not Operational	0	0	0
1976	0	0	NR	NR	0	0	0
1977	0	0	NC	NC	0	0	0
1978	0	NS	NC	NC	0	0	0
1979	0	NS	NC	NC	0	0	0
1980	0	NS	0	0	0	0	0
1981	0	NS	0	0	0	0	0
1982	0	NS	NS	NS	0	0	0
1983	NC	NS	0	0	0	2 *Acipenser*	2 *Acipenser*
1984	NC	NS	0	0	0	3 (1)[a] SNS, 1 (1) *Acipenser*	3 (1) SNS, 1 (1) *Acipenser*
1985	NC	NS	0	0	0	0	0
1986	0	NS	0	0	0	0	0
1987	0	NS	0	0	0	0	0
1988	NS	NS	NS	NS	NS	NS	---
1989	NS	NS	NS	NS	NS	NS	---
1990	NS	NS	NS	NS	NS	NS	---
1991	NS	NS	NS	NS	NS	NS	---
1992	NS	NS	NS	NS	NS	NS	---
1993	NS	NS	NS	NS	NS	NS	---
1994	NS	NS	NS	NS	NS	NS	---
1995	NS	NS	NS	NS	NS	NS	---
1996	NS	NS	NS	NS	NS	NS	---
1997	NS	0	NS	NS	NS	NS	0
1998	NS	0	NS	NS	NS	NS	0
Total	0	0	0	0	0	3 (1) SNS, 3(1) *Acipenser*	3 (1) SNS, 3(1) *Acipenser*

[a] Numbers in parenthesis indicate number collected during a special study of simultaneous sampling at Danskammer Point and Roseton.

Note: NS = No Sampling; NC = No Catch of SNS, samples were examined for only select species; NR = No Report for SNS, only data for select species reported.

Sources: Annual entrainment monitoring reports.

Acipenser = Species unidentified.

TABLE 5-2 ACTUAL NUMBER OF SHORTNOSE STURGEON COLLECTED DURING IMPINGEMENT SAMPLING AT SIX HUDSON RIVER POWER PLANTS, 1972-1998

	Bowline	**Lovett**	**Indian Point Unit 2**	**Indian Point Unit 3**	**Roseton**	**Danskammer Point**	**Annual Total**
1972	No Sampling	No Sampling	1	Not Operational	Not Operational	4	5
1973	1	0	2	Not Operational	0	2	5
1974	1	0	3	Not Operational	1	0	5
1975	0	0	1	Not Operational	0	0	1
1976	1	0	2	0	0	0	3
1977	0	0	6	1	0	1	8
1978	0	0	2	3	0	0	5
1979	0	0	2	2	0	0	4
1980	0	0	0	1	0	0	1
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	3	3
1983	0	0	0	0	0	1	1
1984	0	0	1	1	2	3	7
1985	0	0	0	0	1	2	3
1986	0	0	0	0	0	0	0
1987	0	0	1 (1)	1	0	0	2 (1)
1988	0	0	0 (3)	1	1	0	2 (3)
1989	0	0	0	0 (1)	0	0	0 (1)
1990	0	0	0 (1)	0	0	2	2 (1)
1991	0	0	No Sampling	No Sampling	0	0	0
1992	0	0	No Sampling	No Sampling	0	1	1
1993	0	0	No Sampling	No Sampling	0	0	0
1994	0	0	No Sampling	No Sampling	1	0	1
1995	0	0	No Sampling	No Sampling	1	1	2
1996	0	0	No Sampling	No Sampling	0	0	0
1997	0	0	No Sampling	No Sampling	0	0	0
1998	0	0	No Sampling	No Sampling	0	2	2
Total	3	0	21 (5)	10 (1)	7	22	63 (6)

Note: Numbers in parenthesis indicate number of shortnose sturgeon taken on non-sample days.
Sources: Hoff & Klauda 1979; annual impingement monitoring reports.

TABLE 5-3 ESTIMATED ANNUAL IMPINGEMENT OF SHORTNOSE STURGEON AT SIX HUDSON RIVER POWER PLANTS, 1972 –1998

	Bowline	**Lovett**	**Indian Point Unit 2**	**Indian Point Unit 3**	**Roseton**	**Danskammer**	**All Plants**
1972	1[(a)]	0[(a)]	1[(b)]	Not Operational	Not Operational	14	16
1973	9	0[(c)]	2[(b)]	Not Operational	0	29[(d)]	40
1974	9	0[(c)]	3	Not Operational	7	0	19
1975	0	0	1	Not Operational	0	0	1
1976	4	0	2	0	0	0	6
1977	0[(e)]	0	6	1	0	6	13
1978	0	0	2	3	0	0	5
1979	0	0	2	2	0	0	4
1980	0	0	0	1	0	0	1
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	16	16
1983	0[(e)]	0	0	0	0	5	5
1984	0	0	4	4	13	15	36
1985	0	0	0	0	7	11	18
1986	0	0	0	0	0	0	0
1987	0	0	6	3	0	0	9
1988	0	0	0	4	7	0	11
1989	0	0	0	0	0	0	0
1990	0	0	0	0	0	15	15
1991	0	0	1[(f)]	1[(f)]	0	0	2
1992	0	0	1[(f)]	1[(f)]	0	8	10
1993	0	0	1[(f)]	1[(f)]	0	0	2
1994	0	0	1[(f)]	1[(f)]	8	0	10
1995	0	0	1[(f)]	1[(f)]	7	7	16
1996	0	0	1[(f)]	1[(f)]	0	0	2
1997	0	0	1[(f)]	1[(f)]	0	0	2
1998	0	0	1[(f)]	1[(f)]	0	14	16
Total	23	0	37	26	49	140	275
Per Year	0.9	0.0	1.4	1.0	1.8	5.2	10.2
Last 10 years	0	0	8	8	15	44	75
Per year	0	0	0.8	0.8	1.5	4.4	7.5

(a) Estimated impingement based on yearly average of following 5 years of sampling (1973-1977) and prorated to start of operation in September.
(b) Assumed 100 percent of flow sampled in accordance with applicable Standard Operating Procedures.
(c) Percent of annual flow sampled assumed same as 1975.
(d) Percent of annual flow sampled based on 26 sampling days (from sampling frequency) and 365 operating days.
(e) Percent of annual flow sampled assumed same as previous year.
(f) Estimated impingement based on yearly average of last 5 years of sampling (1986-1990).

APPENDIX A

METHODS AND RESULTS OF LONG-TERM MONITORING PROGRAMS SPONSORED BY THE HUDSON RIVER UTILITIES

A.1 Methods and Collections

A.2 Estimates of Total Annual Impingement of Shortnose Sturgeon

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APPENDIX A.1

METHODS AND COLLECTIONS

APPENDIX A.2

PROCEDURES FOR ESTIMATING TOTAL IMPINGEMENT OF SHORTNOSE STURGEON

APPENDIX A.2

PROCEDURES FOR ESTIMATING TOTAL IMPINGEMENT OF SHORTNOSE STURGEON

A.2.1 INTRODUCTION

The six power plants (Bowline Point, Lovett, Indian Point Unit 2 and Unit 3, Roseton and Danskammer Point) located in the mid-Hudson River estuary ("Estuary") employ a once-through cooling water system to cool the condensers. The cooling systems withdraw large quantities of the Estuary water containing a variety of aquatic organisms of different species and sizes. The organisms found in the cooling water may pass through a plant's cooling system (entrainment) or may be entrapped on the debris screens installed at the intake to the cooling system (impingement). After passage through the plant's cooling system, the water and entrained organisms are discharged to the Estuary. Various screenwash systems are employed at the power plants for periodically removing impinged organisms from the debris screens and either disposing of them or returning them to the Estuary.

Sampling programs and studies concerned with the aquatic effects of impingement have been conducted at each of the power plants since the early 1970s. Weekly sampling for a 24-hour period for impingement abundance and species composition has generally been conducted at Bowline Point, Lovett, Roseton, and Danskammer Point since the start of commercial operation of each plant. At Indian Point, impingement abundance and species composition was monitored daily until July 1981 and thereafter for 110 days per year on a seasonally stratified, randomly selected schedule. Impingement sampling at Indian Point was discontinued in 1991 following the installation of modified Ristroph-type traveling screens.

In order to assess the impact of impingement on shortnose sturgeon, an estimate of the total number of shortnose sturgeon impinged should be determined. Because impingement sampling was not conducted daily at most of the power plants (except at Indian Point prior to 1981), the number of shortnose sturgeon collected during sampling reflects only a portion of the total impingement. These sampling numbers should be scaled by some factor to arrive at a total estimated impingement. Based on the assumption that impingement is directly proportional to flow, a scaling factor based on the percent of total plant flow sampled has typically been used. In support of this assumption, it stands to reason that if there were no flow there would be no impingement. Conversely, if all the water in the Estuary was used, then it stands to reason that all shortnose sturgeon would be impinged. Thus, at least over some range of flow, the number of shortnose sturgeon impinged is proportional to the amount of cooling water withdrawn from the Estuary.

A.2.2 ESTIMATION PROCEDURE

The total estimated impingement of shortnose sturgeon at each of the power plants for each year from 1972 through 1998 was derived from the number of shortnose sturgeon collected in impingement samples and the percent of total plant flow sampled as follows:

$$I_{py} = \frac{N_{py}}{F_{py}}$$

where:

I_{py} = Total estimated impingement for power plant (p) in year (y)

N_{py} = Number of shortnose sturgeon collected in impingement samples at power plant (p) in year (y)

F_{py} = Percent of total plant flow sampled at power plant (p) in year (y).

The number of shortnose sturgeon collected in impingement samples and the percent of total plant flow sampled were obtained from the annual impingement reports produced by the impingement contractor at each of the power plants. If percent of flow sampled could not be determined from the annual reports, then either a value from the previous or following year or a value based on sampling frequency was substituted. If no sampling was conducted at a power plant for a year, then the total estimated impingement for that year was based on an annual average total estimated impingement from either the previous or following 5 years of sampling.

A.2.3 RESULTS

Estimates of the total annual impingement and supporting data for each year are presented for Roseton and Danskammer Point power plants in Table A-17. Similar data for four other Hudson River power plants is presented in Table A-18. These results demonstrate that shortnose sturgeon are impinged at the six power plants listed relatively infrequently. This infrequency is evidenced by the fact that during the 10 most recent years of impingement monitoring at all power plants (1981–1990), shortnose sturgeon were not even collected at any specific plant almost 80 percent of the time.

TABLE A-17 TOTAL ESTIMATED IMPINGEMENT OF SHORTNOSE STURGEON AT ROSETON AND DANSKAMMER POINT POWER PLANTS, 1972-1998

	Roseton			Danskammer Point			Both Power Plants	
	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement	Number of Impinged SNS	Total Estimated Impingement
1972	Not Operational			4	30.55	14	4	14
1973	0	38.82	0	2	7.1[a]	29	2	29
1974	1	16.64	7	0	12.1	0	1	7
1975	0	13.09	0	0	13.91	0	0	0
1976	0	13.87	0	0	14.7	0	0	0
1977	0	17.2	0	1	17.1	6	1	6
1978	0	18.03	0	0	18.38	0	0	0
1979	0	18.2	0	0	17.0	0	0	0
1980	0	17.7	0	0	20.0	0	0	0
1981	0	19.3	0	0	19.7	0	0	0
1982	0	15.5	0	3	19.8	16	3	16
1983	0	16.7	0	1	22.2	5	1	5
1984	2	16.4	13	3	20.9	15	5	28
1985	1	15.8	7	2	19.7	11	3	18
1986	0	14.7	0	0	16.8	0	0	0
1987	0	17.3	0	0	20.0	0	0	0
1988	1	15.7	7	0	18.6	0	1	7
1989	0	14.3	0	0	14.1	0	0	0
1990	0	14.3	0	2	14.2	15	2	15
1991	0	14.4	0	0	14.0	0	0	0
1992	0	14.3	0	1	14.2	8	1	8
1993	0	14.7	0	0	13.7	0	0	0
1994	1	14.1	8	0	14.6	0	1	8
1995	1	14.9	7	1	14.7	7	2	14
1996	0	14.4	0	0	14.1	0	0	0
1997	0	14.4	0	0	14.6	0	0	0
1998	0	14.4	0	2	14.3	14	2	14

Total	7	--	49	22	--	140	29	189

[a] Percent flow sampled based on 26 sampling days (from sampling frequency) and 365 operational days.

TABLE A-18 TOTAL ESTIMATED IMPINGEMENT OF SHORTNOSE STURGEON AT BOWLINE POINT, LOVETT, AND INDIAN POINT UNIT 2 AND UNIT 3 POWER PLANTS, 1972-1998

	Bowline Point			Lovett			Indian Point Unit 2			Indian Point Unit 3		
Year	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement	Number of Impinged SNS	Total Plant Flow Sampled (%)	Total Estimated Impingement
1972	No Sampling		1[a]	No Sampling		0[a]	1	100[c]	1	Not Operational		
1973	1	11.44	9	0	13.9[b]	0	2	100[c]	2	Not Operational		
1974	1	12.32	9	0	13.9[b]	0	3	100	3	Not Operational		
1975	0	14.99	0	0	13.9	0	1	100	1	Not Operational		
1976	1	26.72	4	0	13.9	0	2	100	2	0	100	0
1977	0	26.72[b]	0	0	10.7	0	6	100	6	1	100	1
1978	0	33.17	0	0	13.5	0	2	100	2	3	100	3
1979	0	30.4	0	0	12.2	0	2	100	2	2	100	2
1980	0	27.7	0	0	12.2[b]	0	0	100	0	1	100	1
1981	0	18.9	0	0	10.8	0	0	50.75	0	0	64.48	0
1982	0	16.6	0	0	13.4	0	0	17.64	0	0	30.0	0
1983	0	16.6[b]	0	0	16.1	0	0	26.54	0	0	49.83	0
1984	0	31.2	0	0	13.8	0	1	33.33	4	1	32.16	4
1985	0	29.3	0	0	10.4	0	0	83.3	0	0	41.33	0
1986	0	28.3	0	0	10.8	0	0	35.03	0	0	29.7	0
1987	0	26.6	0	0	8.9	0	1	17.73	6	1	40.4	3
1988	0	28.4	0	0	10.6	0	0	27.91	0	1	29.1	4
1989	0	27.3	0	0	11.1	0	0	30.52	0	0	28.62	0
1990	0	29.3	0	0	10.4	0	0	14.2	0	0	28.08	0
1991	0	13.8	0	0	14.4	0	No Sampling		1[d]	No Sampling		1[d]
1992	0	15.0	0	0	13.0	0	No Sampling		1[d]	No Sampling		1[d]
1993	0	15.1	0	0	12.6	0	No Sampling		1[d]	No Sampling		1[d]
1994	0	14.0	0	0	14.9	0	No Sampling		1[d]	No Sampling		1[d]
1995	0	15.4	0	0	15.5	0	No Sampling		1[d]	No Sampling		1[d]
1996	0	16.5	0	0	15.1	0	No Sampling		1[d]	No Sampling		1[d]
1997	0	14.1	0	0	15.0	0	No Sampling		1[d]	No Sampling		1[d]
1998	0	14.9	0	0	15.7	0	No Sampling		1[d]	No Sampling		1[d]
Total	3	--	23	0	--	0	--		37	21	--	26

[a] Estimated impingement based on yearly average of following 5 years of sampling (1973-1977) and prorated to start of operation in September.
[b] Assumed percent flow sampled was same as previous or following year because actual percent flow data were not found.
[c] Percent flow sampled based on percent flow sampled at Indian Point Unit 1 by assuming the sampling schedule was the same.
[d] Estimated impingement based on yearly average of last 5 years of sampling (1986-1990).

APPENDIX B

EXPLANATION OF CROSS-PLANT CREDIT SYSTEM FOR PERMIT-REQUIRED OUTAGES